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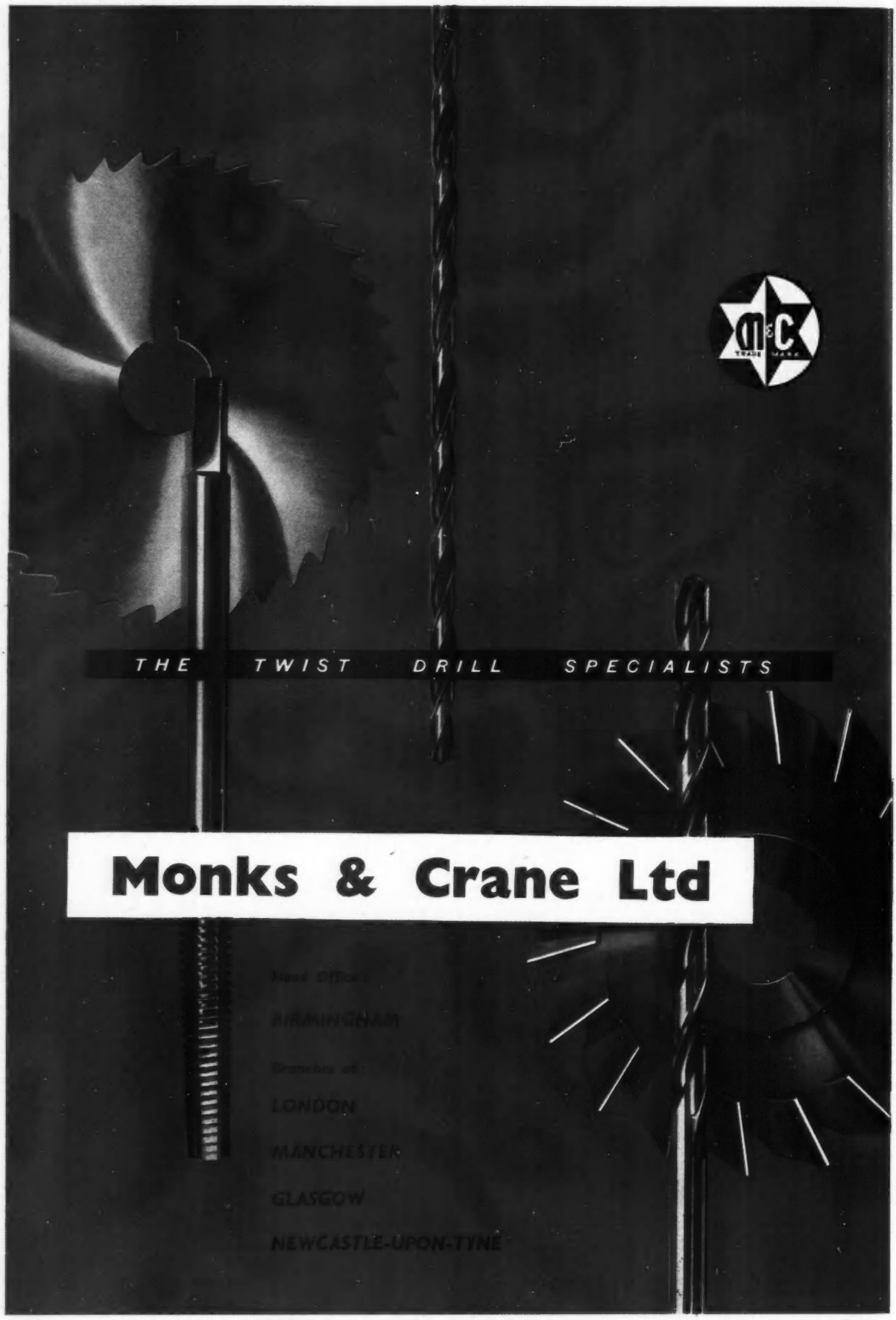
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THE ENGINEER

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FARNBOROUGH AND THE FUTURE

At the time of the last exhibition of the Society of British Aircraft Constructors, we congratulated the industry on displaying aircraft that would appeal to the world as being value for money. During the intervening year we have seen heavy and encouraging sales of propeller-driven aircraft whose virtue is that they fly at a profit, and of jet aircraft, particularly "off-shore" purchases of the U.S.A. In the first seven months of this year, exports exceeded £65,000,000, contrasting with last year's total of £66,000,000. These figures, together with the knowledge that the industry has a labour force of over a quarter of a million, cause us to give close attention to the "shop window" shown to the world. When we find that this year's display features very largely the same aircraft, however, forebodings are aroused, and we are driven to extrapolate the observed trends along a base of time.

One noteworthy point of this year's flying display is that it includes a naval example of the supersonic aircraft. The fast single-seater able to carry a fission weapon is now an established tactical tool and the progress of our twin-engine example will be watched with eagerness. But it must not be overlooked that fighters and research aircraft alike have their wings swept, and the leading edges are at all times subsonic. This form of construction has, of course, been practised world-widely, and its advantages were strikingly brought out by, for instance, Mr. P. J. Duncton in addressing the Royal Aeronautical Society in May. However, there is a limit to this technique. The disadvantages are various, but more serious in the faster aircraft. Increasing knowledge of supersonic flight is placing more emphasis on the reduction of skin friction, and in this respect the delta wing is penalised. The importance of this we cannot estimate, but we recall that the development of the tailless aircraft, notably by Northrop, was inspired by the desire to reduce "wetted area." On the other hand, the swept wing has introduced a host of stressing problems, and that this inherently difficult structure should have to be the first exercise for the new theories of thermal stresses is hardly tolerable. Both plan forms, moreover, have unattractive qualities in conventional landing and take-off manœuvres, and will call for control systems quite extravagant in power. That the limit of the subsonic leading edge is not far ahead is strongly suggested by examples such as the Fairey "Delta II" research aircraft, with its hinged nose, and the Chance Vought "Crusader" carrier-borne fighter, regarded in some quarters as a challenger for the F.D. II's speed record, with its variable incidence wing; and there are already instances of supersonic sections flying successfully on fighter aircraft, such as the mixed power plant "Trident" and the rapid Lockheed "Starfighter." Research aircraft regularly appear in public at Farnborough: the absence of one with even an auxiliary aerofoil uncompromisingly supersonic is disappointing, to say the least.

The prospects of our civil aircraft have altered radically in the last twelve months with the revival of the "Comet" and the disappearance of the Vickers V.1000. An operator has selected a pure jet aircraft for relatively short albeit high-density stages in direct competition from turbo-prop liners. The thirst for precedence may have prompted this decision, but even though air transport in the U.S.A. is far from a field of free competition, only the line that is without benefit of subsidy dare call its soul its own, and this carrier must consider its vehicle at least competitive. If this choice proves to have been correct, then with the advent of the many jets already in production or being designed, the market for our turbo-prop aircraft may shrink to include only the more arduous routes. This makes it all the more regrettable that the builders of what is at present the largest airliner did not secure the collaboration of the major North American corporation that was interested in building a successor for even more economical operation at extreme ranges: this co-operation could, at the least, hardly have failed to reduce the costly and irrecoverable delays experienced during development. Support for the jet airliner also attracts attention again to the V.C.7, commented on in these columns on November 18th last. If the advantages of less noise, less fire risk, and easier installation claimed for the by-pass engine are substantial, it would seem to be axiomatic that the aeroplane should be designed to exploit them, and to counter the increased frontal area of the engines. This contention is borne out by the striking differences between the T.U. 104 and the "Caravelle," the "Bison" and the strategic bombers of the U.S.A. When we

recall the progress that has been made recently in the techniques of fabrication, such as welding titanium, continuous casting complicated sections and stretch-forming major components, it is difficult to reconcile ourselves to the belief that weight control alone failed in the V.1000 design. It is now only doubtfully possible to maintain that there will be a future market for a high-subsonic British airliner : and while the resources of the industry are equal only to a small number of projects it would be unreasonable to attempt to displace established manufactures by offering a product merely marginally superior. For a supersonic liner the prospect is rather uninviting because of the relatively advanced state of the art in the two major air powers, both of which have supersonic bombers at or near the flying stage. A second objection is that regular, practical, supersonic services may prove to depend on some such esoteric technology as that of high-energy (chemical) fuels. These fields are being explored intensively at least by the U.S.A. under an incentive allied to that which brought aircraft interception in Germany in 1944 to a level comparable with that obtaining to-day in the U.K. Equivalent wide-scale efforts could hardly be sustained in this country. It would be interesting to have evidence of the progress being made : it has not been made apparent at Farnborough this year. Another promising avenue of advance for the industry is to exploit its early interest in short or vertical take-off aircraft. If more interest was concentrated, for example, on the " Rotodyne," a convertiplane featuring two systems of sustentation, but apparently not, as so often happens, economically handicapped, and the jet flap, for early flight trials of which suitable turbines would seem to be available in this country, then we might hope to succeed in eventually repelling the insatiable territorial demands of the concrete runway.

WORK OF B.I.S.R.A.

When an engineer visits a large iron and steel works for the first time his initial reaction we suppose (for our first visit occurred a long while ago !), is a feeling of awe. For so much of the plant is very large and so many of the processes carried out are very spectacular. Even the essential bases of what is being done, simple though they are, are not immediately grasped: a few repeat visits are needed to provide familiarity. It is then grasped that ore is reduced to iron in the blast-furnace, that the iron is converted to steel of a specified composition in the melting shop, and that this steel is rolled down to the various sections, sheets, and rounds in the mills to become the raw materials for the engineer to work upon. But though familiarity never breeds contempt it does cause an engineer, rather shyly, to begin to ask quite penetrating questions. Why, for example, if it is steel that is wanted, is it necessary to make the wrong material, iron, to begin with ? Why, when small converters of Bessemer type can produce steel very quickly, are very large open-hearth furnaces so commonly used in this country ? Why, when material of small cross-section like, for example, rods and bars, is to be produced, is the process started from an ingot weighing many tons, which has to be rolled down at a great expenditure of time and power and then cut up into relatively small billets which might have been cast in the first place ? Why so often is an ingot or a billet passed back and forth through the same mill when it could, as a more continuous process, be passed through a series of mills? And so on.

There are, of course, answers to all these questions. Tolerantly the steelmaker will try to explain. And if the questioner is prepared to give up enough time to study the factors involved, he will certainly find himself convinced—as indeed he will have expected to find himself convinced—that the steelmaker really does know his job. Yet the outsider often does ask very illuminating questions because he approaches the problems of a specialist subject with a completely open mind, unobstructed by that very familiarity with a subject that makes men blind to any other approach than the one to which they are used. The answers that the steelmaker will give are utterly convincing only if the steel works processes remain unchanged. If some process of reducing ore other than that which occurs in a blast-furnace is thought of, if some other process of purification is envisaged, if some other means of casting the metal than that of pouring from a ladle into a mould is considered, then new conditions rule and existing arguments will no longer serve. But these, of course, are grounds on which the steel works man will not willingly argue with an engineer. That is why, for an engineer, a visit to one of the research establishments of the British Iron and Steel Research Association is so stimulating. For the men working in the laboratories have no such inhibitions. Like the shyly critical engineer—but with far more knowledge to work upon—they, too, approach steel works operations with open critical minds. They, too, ask why this, that and the other operation is done in a particular way ; and, of course, they go further and do experiments to find out not only whether it is as well done in that particular way as it possibly can be done, but whether there may not be an entirely different way whose advantages are superior. Visitors to the Hoyle Street laboratories in Sheffield this week, when B.I.S.R.A. has been holding Open Days, will have observed both lines of approach under investigation in relation to numerous steel works problems. Work is going on there, for example, on the continuous casting of steel direct from the melting furnace and visitors will have seen 4in square ingots being produced ; the rapid heating of ingots for forging has been demonstrated, the basic idea being that, though within the high-temperature furnace the surface temperature of the ingot will be appreciably higher than the internal temperature, this situation will be reversed within a few minutes of its removal ; the complications of controlling gauge in tandem mills are being investigated on a model three-stand unit so sufficiently equipped with instruments that the reaction of making a change at any one stand upon the other two is immediately revealed. Many other experiments in steelmaking processes, chemical reactions in melting furnaces, forging and drawing processes, hot and cold rolling, pressing and metal working in general have been on view.

The Open Days were held just as the British Association meeting in Sheffield ended. It goes without saying that those attending the meeting were provided with an opportunity to see the laboratories. They also had the pleasure of listening to Sir Charles Goodeve, director of the Research Association, delivering his Presidential Address to Section B (Chemistry) on " Steelmaking Since Bessemer." The Address is reprinted in full elsewhere in this issue, as we think it will prove particularly illuminating to engineers interested in steelmaking processes, and it is a model of clarity. Towards its end it illustrates the point we made earlier in this article that B.I.S.R.A. approaches steel works problems with a mind as open to examine new suggestions as any engineer could hope for. Sir Charles gave some particulars of what is known as the " Cyclosteel " process, by which it is hoped eventually to produce steels directly from ores and apparently to produce them in a continuous process. Bessemer first demonstrated the possibilities of converting iron into steel by blowing through the molten iron fine bubbles of air, the consequent reaction being very rapid. In the " Cyclosteel " process the action is reversed. Droplets of ore are suspended in a reducing flame, producing an equally rapid reaction. By this process some small quantities of what Sir Charles called " very crude steel " have already been made. He remarked of it that " formidable technical obstacles stand in the way and will have to be surmounted " ; and he suspected that " even with all the modern techniques and resources at our disposal it is going to take rather longer than it took Bessemer to get through the practical problems." But that, it will be appreciated, is a confident and hopeful statement. For, from the conception of his idea to its practical realisation Bessemer took a suprisingly short space of years.

A Seven Day Journal

Cross-Channel Cable Project

IT is announced that the Central Electricity Authority and Electricité de France have now received, from the joint committee set up to consider a cross-Channel connection between the electricity networks of this country and France, a recommendation to adopt a scheme for interchange of energy by direct current. For this purpose it is recommended that a single cable capable of transmitting between 120,000kW and 150,000kW at 200,000V be used. If no further difficulties arise, it is hoped that work on the project will begin early next year and that the installation, estimated to cost about £4,000,000, will be completed and ready to go into operation in 1960. A preliminary project for interconnection of the British and French electricity systems by means of submarine cables across the Channel was studied during the latter years of the war. The technical possibilities at the time did not, however, justify a project on a scale which would yield any economical advantage and the project was abandoned. The interconnection problem was taken up again in 1951 and study was eventually concentrated on a project for transmission of power of the order of 150,000kW at 132,000V by three-phase alternating current, which would have involved the laying of four cables, of which one would have been in reserve. New technical possibilities were, however, opened up recently by the development of d.c. transmission, and the a.c. project was not recommended. At the end of 1955, the success of the 100,000V interconnection between Sweden and the island of Gotland, and the progress achieved in the development of high-power mercury vapour mutators, brought out the possibilities, with sufficient elements of certainty, of being able early to attain voltage and power levels suitable for the cross-Channel connection. A fresh study was undertaken in order to provide a comparison between the project for a.c. transmission and a d.c. variant. Finally, the possibility was recognised of undertaking an installation on the scale of 150,000kW at 200,000V, for which a single transmission cable would suffice.

Rejection of the New Barbican Scheme

THE Minister of Housing and Local Government, Mr. Duncan Sandys, has rejected the scheme for the development of the Barbican area: the scheme concerned 47½ acres of severely bomb-damaged land between Aldersgate Street and Moorfields in the City of London. The Minister said that he had been greatly impressed by the imaginative character of the scheme put forward by the "New Barbican Committee"; the widespread interest evoked by its proposals had most effectively focused attention on the need for replanning that important area in a comprehensive manner. But his main difficulty in accepting the scheme was that it contemplated the construction of vast factory, office and other commercial premises, which would have greatly added to the already excessive volume of employment in that area. There was no doubt that, on balance, the plan would appreciably increase the congestion in Central London, and congestion, he affirmed, was London's most serious and intractable planning problem, and we could not afford to do anything which would make it still worse. For this reason he had dismissed the committee's appeal. The proposals provided for a comprehensive scheme of warehousing, office, industrial and residential development, with provision for shopping and schools, and for recreational and communal activities of various kinds, and an open space of a little over three acres around the Church of St. Giles, Cripplegate, and the Roman Wall; and, on an adjacent site of nearly four acres, for a trade hall and a hotel. The greater part of the site was to have been excavated to a depth of from 45ft to 60ft. There was provision for three floors underground; the two lower floors (which would have artificial light and ventilation) were to have been used for warehousing and the upper floor for car-parking space for some 3000 cars. Above ground level it was proposed to build, in three large blocks lying north of the line of the proposed Route 11, a building (or "podium") covering some 15 acres and comprising four floors of offices on the perimeter, and a core of industrial and commercial space on three floors. The top floor, which would have been lit by pavement lights in the roof, was intended for industry, and the other two floors, which would have been artificially lit and ventilated, for warehousing. Three five-storey office blocks, with shops on the ground floor, would have been built south of Route 11, interconnected by bridges and also connected with the blocks to the north of Route 11. There would thus have been a continuous terrace at about 100ft O.D. over the greater part of the site. On this terrace four-storey houses or maisonettes, six seven-storey blocks of flats and five tower blocks (averaging 200ft high, the highest being 300ft) containing mainly offices but also with some flats in the topmost storeys, would have been built. At terrace level there would have been shops, restaurants, public houses, a cinema, schools and a community hall. The scheme included three self-contained road systems—at the terrace level, at ground level, and in the basement.

The Engineer

100 Years Ago

(SEPTEMBER 5, 1856)

"A TOUR IN THE PROVINCES"

"I have now been nearly three months in Manchester; have perambulated most of her principal thoroughfares and byways, and watched the living stream of faces which surges along them. I have looked at and admired her churches and her public buildings of all sorts; listened to the converse of her citizens in all their various moods and phases; visited most of the large manufactories, and seen Manchester both at work and at play; and I have derived both pleasure and instruction from contact with, perhaps, the most active and intelligent community in England. . . .

"There is, I am aware, plenty of pure soft water of the very best quality to be had in Manchester; but why should it all be stowed away in butts and cisterns? How comes it that, in a city so famed for its liberal spirit, the water carts should be the only dispensers of the liquid element? There is not anywhere in Manchester, so far as my observation has extended, anything in the shape of a public pump or wayside well with iron ladle to refresh the parched lips of the wayfarer. There is something very pleasing in the sight of those elegant little granite basins which, in many parts of Liverpool, offer an eleemosynary cup of cold water to all who need it. They remind the poor and the stranger that they are not altogether forgotten or uncared for by their fellow men. Not only Manchester, but most other large towns, would do well to imitate the example of Liverpool in this respect. In those engravings of Manchester, in which the Infirmary forms a conspicuous object, there is quite a profuse display of fountains to be seen; but nowhere else have I succeeded in getting a glimpse of one. . . . One feels under deep obligation to the vendors of patent filters in this weather. The sight of the hydraulic demonstrations in their windows is really most refreshing. . . ."

Damascus Fair

THE products and services of more than a hundred British firms are being displayed at the third Damascus International Fair, which opened on September 1st. For the United Kingdom exhibits a pavilion with an area of 20,000 square feet has been erected for thirty stands, and a further 20,000 square feet of outdoor space is occupied by nine stands. The section has been organised by the Federation of British Industries through its subsidiary company British Overseas Fairs, Ltd. The British exhibits cover a wide range of both capital and consumer goods, amongst which there are strongly represented manufacturers of motor vehicles and accessories; radio and television equipment; agricultural equipment and supplies; engines; pumps; electrical plant, and office machinery. The individual exhibits include a display by the Board of Trade illustrating Britain's contribution to the development of the Arab countries. A television studio and transmitter by Pye, Ltd., has been installed for broadcasting programmes during the fair, and a composite stand arranged by the British Radio Equipment Manufacturers' Association is showing radio and television sets made by seven manufacturers.

Vibrated Concrete

A JOINT committee of the Institution of Civil Engineers and the Institution of Structural Engineers has published a report entitled "The Vibration of Concrete." This report reviews the objects and uses of vibration techniques in concrete construction. Special attention is paid to mix design. It is pointed out that much time was spent in ascertaining the best conditions for the most effective use of vibration, and in showing how a concrete suitable for vibration should be designed. The various classes of vibrators in common use are reviewed, and there are notes on formwork and the practical aspects of placing concrete which is to be compacted by vibration. The committee concluded by listing eleven points for a specification on vibrated concrete additional to the clauses of a normal specification. Seven subjects in which research is needed are suggested. They are as follows: measurement of the vibration of particles, systematically for the various kinds of vibrators; research on the best proportions for immersion vibrators; the development of a simply applied test apparatus for determining the workability of a concrete as it leaves the mixer; research on various aspects of the design of mixes for vibrated concrete, especially lean and gap-graded concretes; research to find the best kind of mixer for the dry mixes associated with vibrated construction; further research into the best frequencies, amplitudes and waveforms for vibrators; generally, investigations into methods of placing the concrete and positioning the vibrators. The report is obtainable from either of the two Institutions; the price to non-members is 8s., and to members 3s. 6d.

Further French Locomotive Experiences

By EDWARD H. LIVESAY

(*Continued from page 295 August 31st*)

No. V—FOUR-CYLINDER COMPOUND TANK ENGINES, PARIS AREA; No. 232-U1, FOUR-CYLINDER COMPOUND EXPRESS ENGINE, PARIS/DOUAI.

TANK engines are employed very extensively on the S.N.C.F., as will be evident to any observer visiting Paris and its environs. They have a variety of wheel-formations, and some are very large, such as the powerful 2-8-2 Dabeg-Cossart valved machines working the double-decked "push-and-pull" local trains out of the Gare du Nord, dealt with in THE ENGINEER of April 9, 1954, and also certain ten-coupled engines. They are used for all kinds of work, passenger, freight, and yard; I had brief encounter with one particularly interesting class when visiting Lens, the 4-8-4, four-cylinder design, with which this article is concerned, which was jotted down in memory as being worth further acquaintance when France was revisited. On asking whether a run might be made with one of them, it appeared that this particular class did not normally work into the Gare du Nord, as I had thought, but on voicing disappointment, instructions were at once sent to the Mitry depot where they were stabled, for one to be taken from its regular duties and put on a local train running to Pontoise for my benefit, a typical example of the consideration invariably shown me throughout both my tours. It would be a pleasant run, as I was familiar with the line, having been over it more than once on the big 2-8-2 machines handled by that friendly crew, Woefflé and Cresson, who came so prominently into the "pull-and-push" article mentioned above. The engine provided was No. 242-A60, 4-8-4, four-cylinder compound, not of recent design, but of a type still doing first class work, and capable of a variety of services, including fairly fast passenger trains. The class is illustrated by Fig. 1, and has the following dimensions and features:

Cylinders:	
H.P. (two), outside	16·5in × 25·6in
L.P. (two), inside	24·8in × 25·6in
Ratio, h.p./l.p.	1/2·44
Driving wheels, dia.	5ft 5¼in
Heating surface:	
Large tubes (21),	490 sq ft
Small tubes (74),	780 sq ft
Firebox	171 sq ft
Superheater	490 sq ft
Total	1931 sq ft
Steam pressure	235 lb
Tractive effort	35,866 lb
Grate area	34 sq ft
Weights as per diagram, total,	118 tons

Walschaerts valve gear, conjugated, single control; piston valves; variable blast pipe; steel firebox; two injectors, no feed-water heater; all wheels braked; air sanding; rocking grate; Flaman recorder; electric light; speed limit 59 m.p.h.

The train, No. 631, consisted of eight double-decked coaches weighing approximately 400 tons; it left the Gare du Nord at 12.05 p.m., in heavy rain, with mécanicien Melliérés, the chauffeur, and the writer in the cab. My invaluable caretaker and linguistic go-between, Monsieur Fillon, should have been there too, but after introducing me to the crew, and explaining the why and wherefore of things to them and me, he basely deserted us for the greater amenities of the next coach, on the plea that he had no overalls with him, and the cab looked as if these were advisable—small, dusty coal, and briquettes stacked at the back. It should be pointed out that these are seldom, almost never, used when running, but are very useful in preventing smoke emission when the engine is in a yard or station, and for quick steam-raising. I only saw them used once out on the road, when for some reason steam was down, and a gradient loomed ahead; if I remember rightly, the grate had been rocked vigorously, and fire-irons used to get rid of clinker, necessitating quick rebuilding of the fire, and recovery of pressure.

The cab, roomy and well-enclosed, was attractive under the existing conditions of wind and rain, giving good protection. The windows were big and the look-ahead in both directions was unobstructed and covered a wide field, a sliding roof making ventilation anything desired, a condition often found to be in inverse ratio to protection. The equipment was lavish, including most of the fittings and indicative gauges one expects to find only on express engines—and seldom found on any engines in Britain. Electric light, Flaman recorder, steam-chest and exhaust pressure dials; variable exhaust control; all these and other luxuries were there, though this was only an ageing tank engine; not even many up-to-date British express engines are blessed with such refinements as these. One of the attractions of riding in a French cab is that one can see at any time what is happening all over the engine; one does not have to travel in blissful ignorance, nor draw on one's imagination—nor perchance on the driver's, which is sometimes even more misleading! Whatever you want to know, there is the information right in front of you, so that he who rides may read.

Mécanicien Melliéres and his mate, whose name somehow was unrecorded, were as usual friendliness personified, and always willing to explain anything not quite clear to me, mostly in dumb show, due to Fillon's absence. The variable blastpipe, worked by a wheel over the reverse gear, was given little, if any, consideration, or if it was, I did not notice it. Possibly this was because, in view of the easy gradients, driving finesse was not really called for; as will be seen from the profile, Fig. 3, there was nothing worse than 1 in 200 anywhere, and this would concern the return trip. The riding of this long wheel-based, well sprung, double bogie engine was very good indeed; it was a pleasure to be on it, despite the shortness of the inside connecting-rods, driving on the first coupled axle, from which some reaction might have been looked for. However, there were two of them, and as the associated cylinders and crossheads were not located very far forward, no disturbance was noticed at the front end, either laterally or vertically.

The management of this somewhat complicated four-cylinder compound was no more difficult than had it been a two-cylinder simple, the two sets of valve-gear being conjugated, and controlled by one wheel in the cab. This is now the practice on all late French compounds, such as the fine 4-6-4, "U1," or the equally noteworthy "P" class 4-8-2 machines. With these, and others with a similar arrangement of valve-gear, it is no longer necessary for the driver to juggle with independent mechanisms to get good results from his engine. The profile, Fig. 3, is generously detailed, and includes the schedule; together, they show that no very great demands were made on this powerful engine, with its 35,866 lb tractive effort working compound, even though the load, 400 tons, was fairly heavy, and the stops frequent—nine in the 20 miles to Pontoise, reached at 12.53, three of them on a rising gradient. The highest speed attained was between 45 m.p.h. and 50 m.p.h., on 1 in 260 up; the boiler pressure was a little down, below 200 lb, and the valve travel 45 per cent both sets, with the regulator under two-thirds open. Under these conditions, the h.p. steam chest gauge read 90 lb, and the l.p. about 20 lb; I do not recall ever seeing the regulator more open than this, and it was generally less, the engine being so obviously master of its job.

I had no fault to find with the behaviour of either engine or crew; certainly not that of the latter, who showed *en route*, and finally at Pontoise, the same good-fellowship that by this time I had come to recognise as common to everybody with whom I associated on the S.N.C.F. It was demonstrated in several ways and at frequent intervals throughout the run; Vin Rouge definitely came into it on this occasion; I prefer this to liquorice-water, administered on previous runs. This, though temporarily satisfying, sooner or later seemed to have a somewhat unsettling effect.

It was a very pleasant excursion, and the return journey to Paris was like unto it, but I did not take notes of this, beyond the fact that the weather had changed from rain to fine, and we returned to the Gare du Nord in bright sunshine. The route, too, had pleasant memories, as I had been over it more than once on my previous tour in the lively company of Messrs. Woefflé and Cresson, the latter being in a way the hero of the "pull-and-push" article on double-deck trains between Paris, Valmondois and other dormitory towns, dealt with in THE ENGINEER of April 9, 1954. Acquaintance, begun at that time, during my first visit to France, was renewed and regard strengthened during the second, which makes the following story apropos; though militating somewhat against chauffeur Cresson's reputation, it deserves recounting because it is a vignette of life on the S.N.C.F., as lived on its Paris suburban services. It is given in the words of a letter from Monsieur Fillon, the official to whom much of the success of several experiences was due, to say nothing of the pleasure.

"You speak of our friend Cresson. Alas, a misfortune happened to him, and I cannot help from telling you the story. On the 22nd of April, the Stationmaster of Pontoise called the P.C.,* and said there was no chauffeur on the engine, No. 141-Tc30, Joncerolles depot, ready to push the train No. 764 from Pontoise to Paris. Departure was 6.55 p.m., and it was then 6.54. The stationmaster said he had sent his clerks for the chauffeur in all directions, but this damned fellow was to be found nowhere. There is no supplementary engine at Pontoise, so we could do nothing but cancel the train, with some other consequences . . . (for Cresson, understood. E.H.L.).

"At last, 40 min past 7, this rascal came back, and said that, as he had plenty of time, he had gone for a walk along the Oise River. It was a marvellous sunny afternoon (probably the only one we have had from the

* The Paris control office, dealing with rosters of engines and crews.—E.H.L.

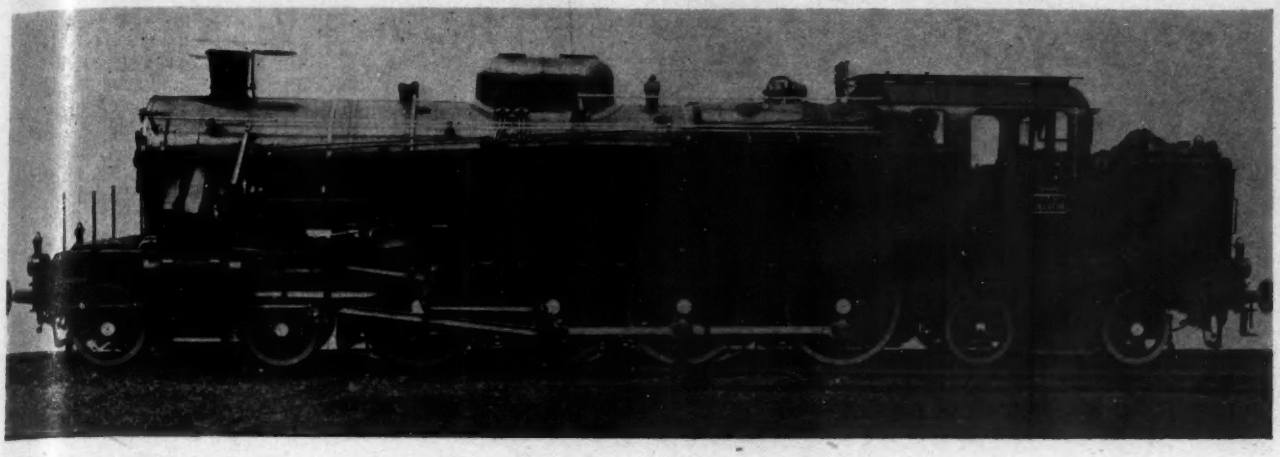


Fig. 1—Four-cylinder compound 4-8-4 tank locomotive

beginning of this spring !), and our fireman—yes, it was Cresson, as you have guessed !—sat down under a tree on the river bank, lulled by the warmth of the sun and the singing of the birds ; in fact, he fell deeply asleep ! Had he too much wine at his lunch ! "

I can picture everything—the environment, the people concerned at the two ends of the line—in particular I can both see and hear what subsequently transpired in the P.C. office at the Gare du Nord, but Monsieur Fillon draws a veil over that. Poor Cresson !

During my first experiences on the S.N.C.F. no locomotive impressed me more than the striking 4-6-4 " Hudson," No. 232-U1 (Fig. 4), fully dealt with in THE ENGINEER of March 5 and 12, 1954. Ever since, I had looked forward to seeing and travelling on it again ; it still appears to me as probably the most advanced and mechanically efficient express locomotive ever built, though the outstanding " P " class 4-8-2 machines run it close. It would be difficult seriously to balance the respective merits of the two designs—except perhaps in the matter of appearance, where " U1 " scores. It is to be regretted that, in the light of present traction trends, these locomotives, the last word of their talented designers, will have no successors. The day of steam as a motive power is drawing to a close in France, as in Britain and many other countries.

For convenience, the chief dimensions and fittings of " U1 " are given :

Cylinders :	
H.P. (two), inside	17·4in × 28in
L.P. (two), outside	27·2in × 28in
Piston valves, actuated by conjugated Walschaerts gear.	
Ratio h.p. to l.p. cylinders	1 to 2·32
Steam pressure	291 lb
Driving wheels, roller bearings and throughout, dia.	6ft 6in
Bogie and trailing truck wheels	3ft 2in
Cast steel frame ; driving springs equalised.	
Heating surface :	
Tubes and flues	1683 sq ft
Firebox	247·5 sq ft
Superheater	866 sq ft
Total	2796·5 sq ft
Grate area, mechanical stoker	56·6 sq ft
Tractive effort, working compound	46,860 lb
H.P.	3500
Weight on :	
Bogie	33 tons
Drivers	67·5tons
Truck	29·5 tons
Engine	130·0 tons
Tender	80·0 tons
Total	210·0 tons
Coal	9·5 tons
Water	7,700 gallons
Speed limit (for track reasons)	88m.p.h.
A.C.F.I. feed-water heater and pump, one live steam injector.; Kylchap double blast pipe and chimney ; Dalmar sand tube cleaner ; air sanding; Flaman recorder and speed indicator; electric light.	

Never having made any secret of my admiration for " U1," nor of my wish to have another run on it, on voicing this, effect was at once given to the request by Monsieur Segaud and other officials, and a trip was dovetailed into the projected three-day tour through North-Eastern France on a variety of freight engines. " U1 " was still working between Paris and Lille, and so could be ridden as far as Douai, where I should have to leave her, my route there branching off for Valenciennes and points east. It would be setting the clock back in several ways ; the train would leave the Gare du Nord at about the same time, and as before would weigh 650 tons ; once again Monsieur Fillon would accompany me in his invaluable role of courier and interpreter, though a prior engagement would prevent Monsieur Leseigneur, Chief of Traction, from driving, Monsieur Leprovost an official of the First Motive Power District acting in his stead. Decaen, " U1's " regular driver, would also be elsewhere, his place being taken by mecanicien Leprêtre, of la Chappelle depot, but Douillet was still " U1's " fireman ; he had not forgotten our first association.

The 650-ton train left the Gare du Nord at 7.50 a.m.; the valve gear and associated mechanism of this engine being unusual, possibly unique, I watched the handling of the regulator and reverse closely ; acceleration was rapid, and there was no slipping. Though a four-cylinder compound, working as a simple only when starting, " U1 " is handled in exactly the same way as a non-compound machine, not only when getting away from rest, but under all running conditions. No additional skill is called for from the driver of this admittedly complicated multi-cylindered compound engine, nor juggling with the controls, which consist of two only, regulator and reverse. At starting, the reverse wheel is put right forward, and the regulator opened according to the load and gradient ; simultaneously a servo-operated device automatically comes into action, allowing temporary admission of steam for 90 per cent of the l.p. cylinder stroke, and 75 per cent of the h.p., at the same time regulating the steam chest pressure of both pairs of cylinders to about the figure for normal running, viz., 261 lb and 72 lb respectively. Things remain thus so long as the reverse gear is right forward ; on the speed increasing, and the cut-off being shortened to 55 per cent in the usual way, this servo-operated device goes out of action and the engine works compound, with the same cut-off in both h.p. and l.p. cylinders. Both h.p. and l.p. valves on each side of the

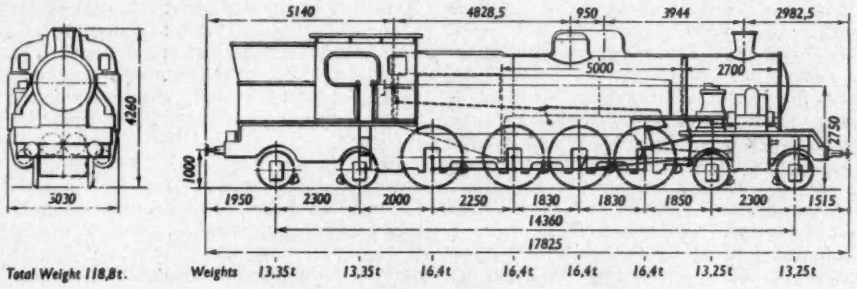


Fig. 2—Weight diagram of 4-8-4 tank locomotive

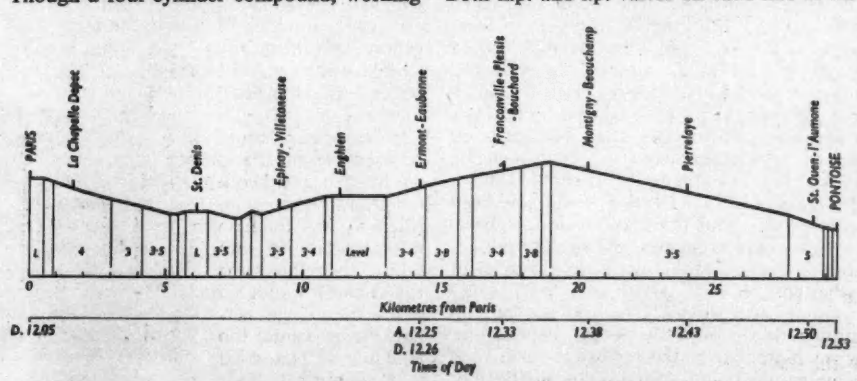


Fig. 3—Gradient profile, Paris/Pontoise. (Train No. 631, eight coaches, 396 tonnes)

Fig. 4—No. 232-U1, four-cylinder compound express locomotive

engine are actuated from the one outside link, the inside valves having, of course, their own combination levers worked from the h.p. crossheads.

Quoting the official description of the engine : "The great advantage of this arrangement is that it enables the engine to be driven in exactly the same way as a simple expansion machine, the driver handling the regulator in the same way as he would on that kind of locomotive. The ease and simplicity of speed and power variation is something quite new in the management of a compound engine. The reverse gear is entirely enclosed, working in oil, and the scale, placed vertically, is very easily read. The distributors, &c., associated with changing over from simple to compound working, and vice versa, are operated by a servo-motor ; everything is automatic, the driver merely altering the valve travel and moving the regulator at his discretion, without being concerned in any way with the other mechanism."

Leaving the Gare du Nord is as a mecanicien would have it—1 in 250 down begins almost at the end of the departure platform, extending with scarcely a break for over 3 miles to St. Denis. No foul tunnel with greasy rails and rising gradient make departure difficult as at King's Cross ; apart from this, exit from the Gare du Nord and the succeeding long pull from St. Denis up the Survilliers bank somewhat resemble the 14-mile stretch to Potters Bar, though the half-dozen tunnels that distinguish the latter are lacking. "U1" was evidently in perfect condition, having only been nicely "run-in" by 1000 miles of operation since complete routine shopping, and the riding was correspondingly faultless ; so easy and springy, of the kind often experienced in France and so seldom elsewhere. The top of the incline was passed at 8.12, the 18 miles—14 of them at 1 in 200—having been covered from a standing start in 22 min, which, with 650 tons, is good work. I wonder if a train of this weight has ever been taken out of King's Cross up to Potters Bar at an average of 50 m.p.h., or whether there is any express engine in Britain that could do it ? I should think a 2–8–2 "Cock o' the North" would have been capable of it, but this class no longer exists as eight-coupled engines, and in their present shape would probably have insufficient adhesion.

On this occasion "U1" did not put up quite such a good show as two years before, when it went over the top with steam near popping-off point—291 lb—and with h.p. and l.p. steam chest gauges reading 260 lb and upwards of 110lb, respectively. This time, with speed 55 m.p.h., the pressure was a little down, to 265 lb, at the summit, and the steam chest gauges showed 176 lb and 60 lb ; it looks as though the regulator was not fully open, but I did not notice its exact position so can give no explanation—possibly the fact that Monsieur Leseigneur was not handling it ! "U1's" regulator must be treated with respect when the engine is extended, as the factor of adhesion is only 3·24, the one and only feature that I am inclined to criticise ; it is on the low side. This can also be said of a certain class of British engine for which I have great admiration, the "Princess Coronations," with adhesion factor 3·75 and a tendency to slip under stress. Was it not once an axiom that anything under 4·00 was questionable, or did this only apply to two-cylinder engines ?

From the Survilliers peak "U1" dropped down the long declivity at 75/80 m.p.h., through the Forest of Chantilly to Creil, the speed being restricted to 60 m.p.h. through the yard and station ; 8·25, 31 miles in 35 minutes. Then came the 23-mile climb through St. Just, passed at 8·45, 50 miles in 55 min, to the Gannes summit. Neither the heavy load, 650 tons, nor the considerable gradients gave chauffeur Douillet any concern; the mechanical stoker ceaselessly bringing screened coal to the 56 square feet grate, and the ACFI feed-pump rhythmically forcing exhaust-heated water into the boiler made his job merely a matter of watching and adjusting, not working and sweating. The blow-down was opened for 30 seconds every 30 miles, each ejection taking 75 gallons of chemically treated water from the boiler. Fillon suggested that roughly 30 gallons of water would be used per mile, and 45 lb of coal ; both quantities were considerably less than on my previous trip with "U1" over this same route, and I wondered if my friend was perhaps being a little too laudatory. He added that about 3 tons of coal would take us over the 155 miles to Douai ; the bunker holds 9·5 tons. A slight temporary drizzle brought the window-wipers into action ; I do think that every completely equipped express engine should have these refinements, but they are still seen all too seldom—even in France !

At Longeau, 84 miles, we left the main line to Amiens and Calais, branching off to the right between chalk cuttings on a steadily rising 1 in 200 gradient, through Albert to another peak at Achiet. The weather was clearing, the sun breaking through and lighting up the great rolling wheat fields, of stubble and stook ; a country nostalgic of the First War, of which there were many indications—monuments on the skyline, as at Thiepval, Villers-Bretonneux, and other places—cuttings pock-marked with shell-holes—ageing stumps among the small second growth trees planted to replace shattered woods. Arras, 9·51, 119 miles in 121 min, succeeded by a fast 16-mile down-hill stretch to Douai, 135 miles from Paris, covered with two stops, in 140 min, 58 m.p.h. Here Fillon and I left "U1" to proceed by "Autorail" to Valenciennes and lunch. It had been a very enjoyable run on an outstanding engine in perfect condition. The fine riding of "U1" and of most French engines always rouses my enthusiasm and, recently, after considerable experience of a certain class of British engine with rather a poor reputation in this respect, it occurred to me that the great weight carried by the leading bogie of French locomotives, due to the concentration at the front end of four cylinders and their associated gear and piping, must have considerable bearing on the matter. The bogies of typical British "Pacifics" carry about 22 tons, as against "U1's" 33 tons. At the other end, too, the engine carries 29·5 tons on its trailing truck, while the corresponding British figure on the trailing axle is about 17 tons or less. This great weight at both ends of "U1" must have a considerable steadying effect.

Diesel-engined, two-car "auto-rails" built on somewhat similar lines to those coming into use on British Railways are running in various parts of France ; noticing them at the Gare du Nord, and being told they ran to Creil, a town 31 miles north of Paris, on the main line to Amiens, I boarded one, my "Autorisation Speciale" empowering me to do so, covering as it did all kinds of motive power. The driver happened to be a new hand, under instruction by the regular mécanicien, and I was invited to sit beside

Fig. 5—Three-car diesel-engined express "Autorail"

him, which made the trip all the more interesting; we both had things to learn. It was a four-speed preselected machine with a 100km top limit; a speed indicator took the place of the usual Flaman recorder, the only instance of this I came across; further, signals were not audibly relayed into the cab. Acceleration was rapid, the preselection of gears simplifying the control; third speed was engaged at 65km, and fourth at 75km.

At Orry-le-Ville, the first stop, motor trouble developed on restarting, the engine refusing to take up the load; so reluctant and fractious was it that we got away finally 3 min late. The mécanicien had gone back to solve the problem, reappearing with a broken part, which he showed me, but my French being equally defective, I could not fathom what had gone wrong. Once under way, everything seemed normal, with the speed, if anything, higher than before to make up the lost time—no French driver is ever content to remain behind schedule if it can possibly be regained—a bonus for time recovery acts as a forceful spur, even without professional pride as an additional incentive. The same trouble recurred after the Chantilly stop, and again further along when a doubly unwelcome signal brought us to a stand, though by this time the regular mécanicien had taken over the controls. Arrival at Creil was several minutes late naturally, for which the driver was very apologetic, but I assured him "*n'importe—ne faites pas d'excuses!*"

Diesel two and three-car trains of various types have been used quite extensively in France for many years, some being pneumatic-tyred; it will be remembered that Michelin-equipped railcars were given trials in Britain also before the war. At Lyons I had noticed cars with the driver's cab raised above the roof, giving a very good all-round view; this would be difficult, if not impossible in Britain, due to our more limited loading gauge, unless the frame was dropped. The most striking diesel-driven cars I saw were the streamlined three-unit German-built trains running from the Gare du Nord to Cologne, which are really fast; they—or something very similar—are seen in Fig. 5.

On several occasions in France I was invited to drive, but modesty—coupled perhaps with some lack of confidence in my ability to do anything like justice to fine engines with unfamiliar controls—led me to decline the privilege. There was one exception, where the big 2-8-2 "push-and-pull" tanks were concerned; I had ridden these so often with Woefflé and Cresson that the operation of these powerful machines had become almost hackneyed. Both regulator and reverse were easy to handle, and adhesion was so ample that only gross carelessness could induce slipping; they seemed equally amenable to discipline no matter which end of the train they were at. When at the rear, the fireman is alone in the cab, and in addition to his main duty, attends to the starting of the train in response to orders coming over the 'phone and loudspeaker from his superior at the other end; stopping is the prerogative of the latter. Several trips were made on these fine engines to Valmondois, Pontoise and Ermont-Eaubonne, and also on "accommodation" runs made for the convenience of workers at suburban points between the Gare du Nord and the Joncerolles depot, which was, I think, given over exclusively to the tank engines, leaving the la Chapelle depot to take care of express motive power.

(*To be continued*)

Optical Instrument for Measuring Camber on Large Rolls*

By P. W. HARRISON, B.Sc. (Eng.), A.M.I.Mech.E., A.C.G.I.

An instrument has been designed and constructed at the National Physical Laboratory to measure the camber of the top surface of rolls, such as those used in paper and metal sheet mills (which may be as much as 25ft long and up to 15ft in diameter) to an accuracy of ±0·0005in under optimum conditions. It has been designed to operate in a restricted space so that static tests can be made on the roll while in the machine. The instrument consists of three components; a light source with a single horizontal slit, a double slit and a micrometer-controlled graticule of novel design. Young's interference fringes produced by suitably positioning the slits provide an optical datum plane to which the roll surface is referred. The slits have been made by a new method, and the double slit is so mounted that the instrument can accommodate considerable positive or negative camber on the roll to be measured.

THE instrument described and illustrated here has been designed and made at the National Physical Laboratory, Teddington, Middlesex, to measure the camber of the top surface on very large rolls such as those used in the paper-making industry. Due attention has been paid to the need, on occasion, to measure the roll while in position in the machine; this condition can impose considerable restrictions upon accessibility, affecting both the equipment and the observer.

Optical Principle

The instrument makes use of Young's interference fringe patterns to provide an optical datum plane to which the surface contour can be referred. The use of Young's fringes for alignment work was first suggested by van Heel, and a brief description of the underlying theory is as follows.

In the classical experiment undertaken by Young (1773–1829), rays from the sun were allowed to pass through a small hole *A*, Fig. 1, and then through two small holes *B* and *C* in a second screen, the light being received on a third screen at *D*. Young observed that interference bands were formed in the region *XY*. According to the wave theory of light, holes *B* and *C* act as coherent light sources and, provided that the holes are equi-distant and sufficiently removed from *A*, the approximately plane wave-front at *B* will be in phase with that at *C* as they both

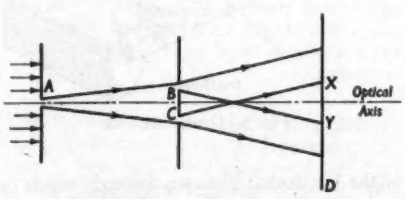


Fig. 1—Principle of Young's experiment demonstrating interference fringes

emanate from the same source. For white light the waves emerging from *B* and *C* either interfere or superimpose to form a fringe pattern such as that shown in Fig. 2. The typical fringe pattern over most of the viewing range is symmetrical about a central band of white light flanked on either side by two relatively dark bands, which will be referred to as the "setting lines." These bands are orange-red on the inner edge, graduating through very deep purple to blue on the outer edge. The rest of the pattern is composed of multi-coloured bands substantially equal in width, the brightness rapidly diminishing as the distance from the pattern centre increases. When the pattern is viewed close to the double holes its appearance changes somewhat, but it is still a symmetrical pattern with two closely defined setting lines.

It will be appreciated from the above that the fringe pattern formed will be symmetrical about an axis passing through the middle of the single hole and the mid-point of the double hole, providing the plane of the holes is reasonably square to the axis. The pattern will therefore form a ready means of setting

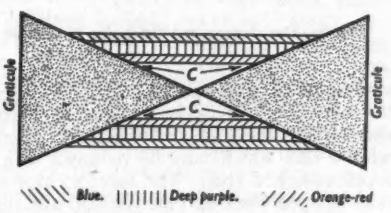


Fig. 2—Typical interference fringe pattern produced by white light with the system of slits shown in Fig. 1

a third point on this axis, provided that brightness and colour intensity of the pattern can be maintained over the required range.

Optical and Mechanical Design

As in earlier apparatus† using this principle, the holes are replaced by slits, the proportions of which have been selected to provide the necessary brightness of pattern over a range of about 1ft to 15ft from the double slit; Fig. 3 is a general view of the apparatus in which the slits have been embodied. It consists of three units which may be referred to conveniently as the single slit, the double slit and the viewing unit. All units have a rectangular platform upon which the optical parts are mounted, each platform having four ball feet which sit on the roll to be measured and are held in blocks screwed and dowelled to the platform. The balls protrude slightly below the under face of the blocks. Of the four balls, two are positioned in a transverse plane containing either the single or double slit or the graticule; the height of these optical parts above the roll is therefore controlled by the ball pairs so placed. In order to ensure that the slits and graticule rise and fall to the same extent when the units are transferred between rolls of different diameter (the need for which will be apparent later), the separation of the balls in the three pairs has been made the same to within 0·0002in. Small bubbles mounted on the platforms enable the latter to be levelled when resting on the roll and ensure that all

* Communication from the National Physical Laboratory.

† Harrison, P. W., 1954: "Interferometric Alignment Set," THE ENGINEER, Vol. 197, page 670.

three units are brought into line on the top generator.

The more detailed drawing of the single slit unit, Fig. 4, shows the single slit *A* illuminated by a bulb *B* (a 6W, 12V type commonly used in automobiles), the light from which passes through a small condenser lens *C*. In the prototype instrument the slit edges were formed by knife-edged steel plates, but these have been superseded by a slit made in a proprietary material, clear "Astrascribe." This is transparent plastic sheeting, in this case 0·010in thick, coated with a wax which may be removed with a sapphire-tipped tool. The sheet so exposed may be dyed black and the residual wax then dissolved away, leaving a black line with sharply defined edges; two such lines are used to form the slit boundary. Roughening of the surface in the vicinity of the slit helps to increase the opaqueness of the material when dyed. In this instance the sheet is mounted after processing in a metal frame held in position by screws in oversize slots, this arrangement permitting some adjustment of slit height and orientation. It may be necessary, on occasion, to position the single slit over the extreme end of the roll; this may be done by slewing the entire optical system on the platform into the overhanging position shown by the dotted line (Fig. 4), the slit remaining in the same relationship to the ball feet as before. However, the ball pair controlling the slit height can now be placed very close to the roll end.

The double slit *D* (Fig. 5) is made and mounted in a manner similar to the single slit, and is secured to the block *E*. This block, which is loosely guided by the studs *F*, may be moved up or down in relation to the platform by known amounts using suitably shaped packing pieces *G*, which may be added or removed when the clamping screw *H* is slackened.

The two principal parts mounted on the platform of the viewing unit are the micrometer-controlled graticule and the telescope assembly. The first assembly consists of block *I* (Fig. 6), in which a photographically prepared graticule is fixed. The block is mounted on the spring strip system *J* which allows it to be moved vertically without friction. The outer race of a small ball-bearing *K* fixed in the block rests on a hardened and lapped land on the wedge *L*, which is, in turn, supported on two steel balls *M*: these locate in a vee-way formed on the bottom face of the wedge. Sideways location of the upper edge of the wedge is provided by two setscrews *N* in the block *I*. The wedge angle is such that the vertical motion imparted to the block is one-third of the horizontal distance through which the wedge is moved. The wedge is driven by the micrometer head *O* through an extension rod which bears on a ball set in the wedge; the rod and wedge are linked by a claw *P*. It may be seen from Fig. 2 that the form of the graticule is two black triangles having their apices touching; the method of setting it on the interference pattern is to raise or lower it until the light cups *C* run equally up the sides of the triangles. Both pattern and graticule are viewed by the telescope assembly (Fig. 7), which consists of a small telescope *R*, a front-aluminised mirror *S*, and a weak field lens *T*. To reduce stray light entering the system and fogging the pattern, a small tubular shield of aluminium is hung over the graticule block *I*. To permit viewing in either direction the telescope assembly may be reversed in its forked bracket, and the shield pointed in the opposite direction. The whole arrangement results in the eyepiece and micrometer thimble being offset quite appreciably from the optical axis, and this, in association with the squatness of the units, enables measurements to be made on a roll *in situ* when little clearance can be provided between it and an adjacent roll lying above it.

Certain adjustments are necessary when first assembling the apparatus. The procedure is to place the double-slit unit on a surface plate with the slit holder set at the mean height provided by the packing blocks. The slits are then observed with a micrometer microscope and the frame orientated to bring the slits parallel to the plane of the surface plate. The unit is replaced by the single-slit unit, and the latter slit orientated in a like manner and set with its centre at the same height above the surface plate as the centre of the double slit. Finally, the viewing unit is placed in front of the microscope and the block *I* raised until the apices of the graticule triangles are brought to this same height. The reading on the micrometer head in this condition is noted. If the units are now placed in line with their ball feet on a flat surface, first the optical datum line will be parallel to that surface, and secondly, the

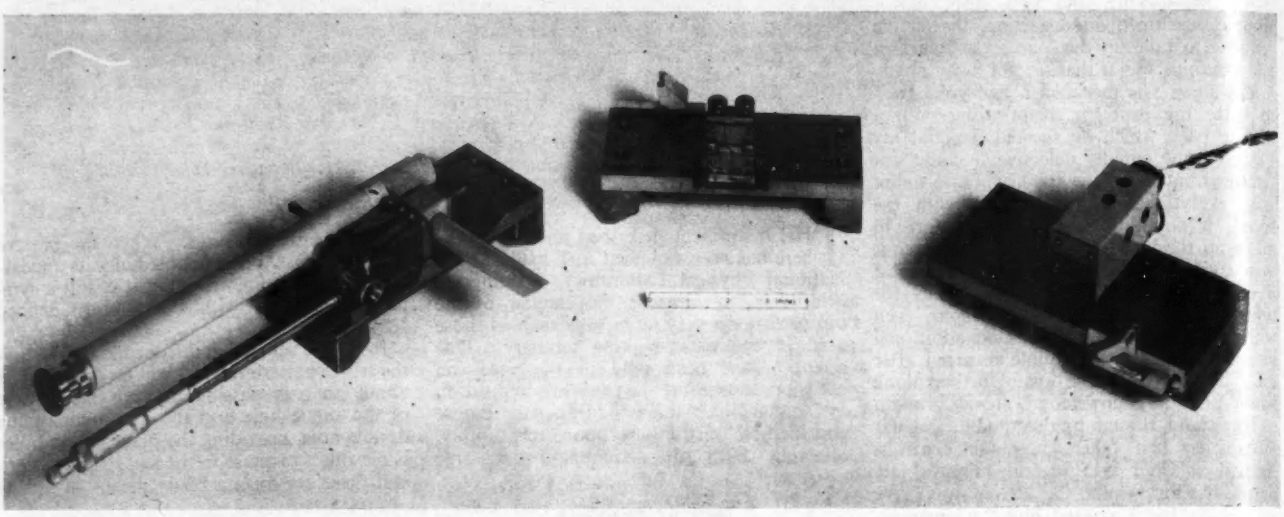


Fig. 3—The viewing unit (left), the double slit unit (centre) and the single slit unit (right) which constitute the instrument for measuring camber on large rolls

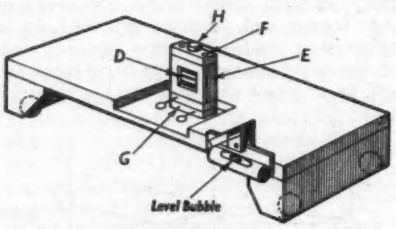


Fig. 5—Double slit unit

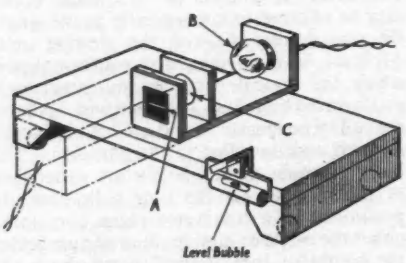
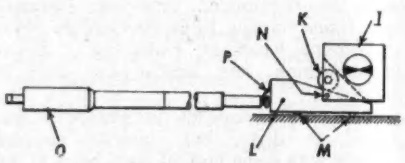
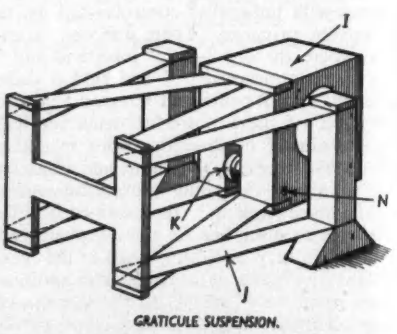


Fig. 4—Single slit unit



GRATICULE HEIGHT CONTROL.



GRATICULE SUSPENSION.

Fig. 6—Viewing unit

graticule will appear centrally on the fringe pattern.

When the units are transferred to a roll the relative heights of the slits and graticule will be determined by the two longitudinal generator lines with which the ball feet are in contact. Having regard to the manner in which the rolls are machined, it is considered that, in general, any characteristic shape of the generator will persist over that part of the periphery embraced by the feet, and that the two generators contacted will therefore accurately reflect the shape of the top generator

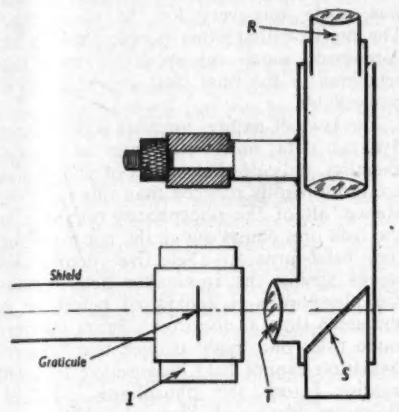


Fig. 7—Optical system of viewing equipment

on a parallel roll. If, in a particular case, this assumption were not warranted, the apparatus could be modified by positioning two of the ball feet directly beneath the optical axis and hence on the top generator.

However, a correction may need to be applied to the camber as measured if the roll varies considerably in diameter along its length, as this variation affects the height relationship between the top generator and those contacted by the units.

Method of Use

The normal practice is to locate the viewing unit and single slit at opposite ends of the roll to be measured, the double slit being placed at its centre. A check is then made that the fringe pattern falls within the range of measurement of the viewing unit, if necessary adjusting the packing pieces under the double slit to ensure this condition. The graticule is set on the pattern and the micrometer reading noted. The viewing unit is then moved towards the double slit, observations being made at any desired interval along the generator. When one half of the roll has been treated in this manner the single slit and viewing unit are interchanged and the procedure repeated on the other half of the roll. Measurements could be taken, of course, moving any one of the three units, but the viewing unit is to be preferred because observations so made require the minimum of treatment to derive the generator shape, and it is particularly convenient for a single operator both to position the unit and to make the observations.

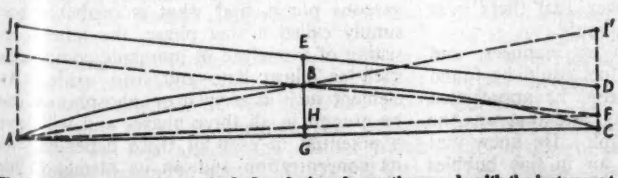


Fig. 8—Diagram showing method of analysing observations made with the instrument

The optical properties of the system limit the minimum separation of the units, and consequently it may be desirable when measuring rolls less than 5ft long to adopt a second method. In this both the single and double-slit units are placed on a surface adjacent to the roll so that the optical datum line still lies above the top generator on the roll and is reasonably parallel to it. The viewing unit is then traversed along the whole length of the roll at any desired interval, its position in relation to the optical datum being measured as before.

Analysing the Observations.—The case considered is that of a heavily cambered roll necessitating a reduction in thickness of the packing pieces under the double slit.

The roll surface is represented in Fig. 8 by the line *ABC*, and the height of the single and double slits above their feet by *CD* and *BE* respectively. *BE* is less than *CD* by the amount *CF*, equal to the reduction in packing piece thickness.

The central camber *BG*

$$= BH + GH = \tfrac{1}{2}(AI + CF).$$

CF is known and *AI* is the measured offset of the point *A* from the line *IBF* and equals:

$$\frac{\text{Micrometer reading at } A}{3} - \left(\frac{\text{Datum micrometer reading}}{3} - CF\right).$$

The factor 3 is introduced to take into account the action of the wedge.

The first term in the bracket corresponds, of course, to the graticule being set at a height *CD* above its feet. As stated earlier, it may be necessary to apply a correction to the value of *BG* so obtained if the roll diameter varies appreciably. A sufficiently precise expression for the correction is :

$$-\tfrac{1}{4} \times \left(\frac{\text{span of ball feet}}{\text{roll diameter}}\right)^2 \times (\text{variation in diameter from the end diameter}).$$

The information obtained enables the points *A*, *B*, *C*, *I* and *I'* to be plotted. Offsets from *BI* and *BI'* for other points on the roll surface can then be quickly derived and plotted, if necessary applying the above correction.

Performance of the Apparatus.—The accuracy with which this apparatus measures roll camber is principally controlled by two factors, namely, the atmospheric conditions and the roughness of the roll surface. The best results are obtained when the interference pattern is brightly coloured and steady ; this requires a little care in avoiding the entry of too much stray light into the viewing system, and, as far as possible, the elimination of hot and cold draughts along the optical path which, by producing variations in the refractive index of the air, can cause the image to flicker.

On steel rolls the roll surface is defined no better than the surface finish permits, and this may in itself restrict the accuracy with which the camber can be measured. A somewhat different situation exists on rolls made of material such as granite because they often have a highly polished surface which is nevertheless deeply pitted. When measuring such rolls care is required to position the ball feet clear of any pits. However, given optimum atmospheric conditions and a good surface finish on the roll it is considered that the camber of the top generator on a roll 25ft long can be determined to an accuracy within ±0·0005in.

The size of roll on which this apparatus can conveniently be used is up to 25ft in length and between 1ft and 15ft in diameter.

The work described above was carried out as part of the research programme of the National Physical Laboratory and this article is published by permission of the Director of the Laboratory.

Steelmaking Since Bessemer*

By SIR CHARLES GOODEVE, O.B.E., F.R.S.

In his Presidential Address to Section B (Chemistry) of the British Association, here reprinted in full, Sir Charles Goodeve, starting from the inventions of Bessemer, reviewed the progress made with pneumatic steelmaking processes, referring on the way to the Gilchrist-Thomas process, and modern developments in the use of "tonnage" oxygen and in top blowing. Finally he described briefly the "Cyclosteel" process, now in its earliest stages of development by the British Iron and Steel Research Association, in which the Bessemer idea of dispersing air bubbles in a liquid metal is reviewed : droplets of ore are suspended in a high temperature reducing gas.

THE British Association has a long history of contributions to the "advancement of science." It is justifiably most proud of the fact that its summer meeting exactly 100 years ago was chosen as the place to announce a discovery which was to have an effect upon civilisation ranking amongst the most important in the history of mankind. At Cheltenham on August 11, 1856, Mr. Henry Bessemer told of a new method of making steel, a method which was, at least in principle, extremely simple and cheap. This exciting announcement was fully reported in *The Times* a few days later.†

The speed with which Bessemer, working at St. Pancras almost alone, brought about the original successes which led to his announcement ; the awful set-back and disappointment which followed when he tried to make the process work in the steel works of his licensees ; the even harder work, now with the help of some others, which finally won through to ultimate success—all add up to a classic which is a prototype for the story of many inventions. Bessemer had already achieved financial independence through his invention of a method for making bronze powder for gold paint, and one which was very much cheaper than the existing methods. He took advantage of this independence to press forward with his experiments at a fast rate. Bessemer was a determined and courageous man, and the set-back only spurred him on through the usual frustrating period of bringing a new discovery into commercial use. His story has set an example and given courage to many inventors.

Much has been said in this centenary year about the discovery itself, the developments

* Address delivered at the Sheffield meeting of the British Association on August 30, 1956.

† And in The Engineer, August 15, 1856.

which followed and the revolutionary consequences of the introduction of tonnage steel. I propose to talk about the chemistry of this high-temperature process, and in particular about that chain of chemical development which was started by Bessemer and indeed has not yet finished. I refer to the making of steel by pneumatic processes.

Steelmaking, because of its importance, has led the way through most of the last 100 years in technical progress in high-temperature chemistry. In recent years, however, processes to make metals such as titanium, which require still higher temperatures, are sharing this leading position.

Let me recall for you the chemical problem faced by steelmakers to-day, a problem which is much the same as that faced by Bessemer. Iron ore is essentially burnt iron or iron oxide, mixed with oxides of other metals, principally silicon, aluminium and calcium. The first stage is to " un-burn " the iron or deoxidise it to form the metal, which, being heavier and insoluble in the remaining oxides, will, if hot enough to be molten, separate from the other components. However, in doing this one has to deoxidise selectively to make sure that one does not bring into the metal a large number of impurities. Fortunately, this can readily be done, so that little of the silicon, and none of the calcium and aluminium, comes into the metallic state. However, one cannot prevent all the phosphorus and some sulphur, commonly present in the ore and in the fuel respectively, coming into the metal.

A cheap and simple deoxidising agent is carbon in the form of coke, and this, when mixed with iron ore in the blast-furnace, carries out the necessary reduction very efficiently and rapidly. It is not practicable to stop the process of deoxidation at the right place, and the metal which comes out of the blast-furnace is over-deoxidised and contains a large quantity of carbon. This amounts to only about 4 per cent by weight, but represents nearly 16 per cent of the atoms in the metal. This iron-carbon alloy corresponds to a stable chemical stage in the process, and therefore one which is exceedingly difficult to avoid, if carbon is used. It does, however, present other problems and these are the problems facing the steelmaker.

Once liquid pig iron is made, the problem is to reoxidise it to remove the carbon and possibly other impurities. Before the days of Henry Bessemer this was done by rabbling or stirring with molten iron oxides in what is called a puddling furnace. This process, which is still carried on to-day in some remote parts of England (!), operates in three main stages. The first of these is one of the oldest purification processes known to chemists, that of crystallisation. To understand this, I must remind you that pure iron crystallises at a temperature of 1535 deg. Cent. The melting point of pig iron, on the other hand, is reduced by the presence of the carbon and other impurities to somewhere near 1100 deg. Cent. The puddling furnace operates at a temperature just above this. When half the carbon has been removed by oxidation through reaction with the iron oxides, iron crystals begin to form, and these are, like most crystals, purer than the melt from which they have come.

However, they still contain more than 1 per cent carbon and this is removed in a second stage. The crystals are stirred with the molten oxide slag so that the carbon, on diffusing to the surface of the crystals, is oxidised and boils off. Very low carbon contents can be obtained in this way.

The final stage consists of raising the temperature and forming a ball of iron crystals, with some entrapped slag, on the end of a rabbling rod. These crystals cannot be separated by gravity as a liquid iron does in the blast-furnace, but a partial separation from the slag can be achieved by skilful squeezing under a hammer.

The process requires great skill and is an extremely slow and arduous one. Two to three hours are required to produce one-quarter ton of metal. The first stage is limited by the difficulty in stirring rapidly enough to promote a chemical reaction between a viscous slag and a heavier molten metal beneath it, and the second stage depends on diffusion in the solid metal phase. There are important physical limitations as well, especially in the third stage of slag removal under a hammer. The iron itself, known to you all as "wrought" iron, has some good qualities, but is much inferior to modern steel.

The open-hearth furnace, which was invented shortly after Bessemer's converter, operates in a way similar to the first stage of the puddling furnace in that a slag containing iron oxide must react with a bath of melted steel scrap to which has been added liquid or cold pig iron. However, the chemical reaction in the open-hearth furnace is much faster than that in the puddling furnace because it operates at a temperature nearly 400 deg. higher. Hand stirring is now impossible, but the carbon monoxide gas evolved comes off fast enough to give a reasonable stirring action, and the oxidation of many tons of metal is brought to completion in a matter of five to six hours. A modern large open-hearth furnace will produce a ton of steel every three minutes.

We can now have a look at what Bessemer did. Instead of supplying the oxygen in the form of iron oxide, he decided to use the very simple and cheap method of blowing air through the metal itself. The cost of his oxygen was therefore only that of running his pump. It must have taken a great deal of courage and skill to have tried such a thing with the equipment available at that time. The speed of his process was limited only by the fact that too great an air flow might blow the iron out of the top of his converter. The chemical reaction was now extremely fast, about a thousand times faster than the puddling furnace of that day. Indeed, a modern Bessemer vessel one-tenth the size of a modern open-hearth furnace can convert 8 tons of iron to steel in the three minutes that the open-hearth takes to convert 1 ton.

We do not have to look far for the cause of this tremendous difference. We now know that at steelmaking temperatures, where the molecules move at high velocities, a good proportion of the collisions between potentially reactive molecules are successful simply because these collisions occur with great force, a force sufficient to overcome the resistance to chemical change caused by the stability of the original molecules. In the language of physical chemistry, a reasonable proportion of the colliding molecules have the required "energy of activation." The rates of iron and steelmaking reactions are therefore governed by the rates at which collisions between the right kind of molecules occur, and this, in turn, is governed by diffusion and by the rate of mixing. We will see presently, however, that there is at least one exception to this rule.

Henry Bessemer was an engineer, and while spotting that his fuel could be found in the carbon in the iron, he appreciated the importance of mixing, and that was the basic cause of his triumph. He knew that he had to disperse his air in fine bubbles in the molten metal to give a large area of gas-metal interface and to agitate the mixture violently.

However, Bessemer could not get out of his difficulties because he was not a physical chemist. One could hardly blame him for that, because the breed was not known at that time, despite the extensive hybridisation of scientists that had already taken place.

What went wrong with the Bessemer process immediately after the announcement? The steel made in his experimental work at St. Pancras was perfectly all right, but steel made anywhere else was useless. It was soon found that, by a lucky chance, the pig iron from which the first Bessemer steel was made was very low in phosphorus. The pig iron that other people tried to use contained more phosphorus, and this remained in the final steel and rendered it unworkable.

The laws of nature, together with thermodynamic data, now well known to physical chemists, indicate that oxides of phosphorus are more readily reduced than those of iron. Hence, all of the phosphorus originally in the iron ores comes out in the pig iron from the blast-furnace. Selective deoxidation works against the ironmaker here because the phosphorus is deoxidised before or at the same time as the iron. From the very same rules one might deduce that selective oxidation cannot help because the iron will oxidise before the phosphorus. Indeed, Bessemer blew and blew his phosphorus-containing iron, burning half of it away without making any impression on the phosphorus. He finally gave up trying and confined his process to iron produced from very low-phosphorus ore. Fortunately, there was such an ore in Cumberland, and the process operated successfully there, and it still does until this day. In the United States there are great deposits of low-phosphorus iron ores, and accordingly the process got away to a very good start in that country. Indeed, the great railway expansion that took place nearly a hundred years ago owes itself entirely to the Bessemer process.

It was left to a young chemist with a good scientific training, Sidney Gilchrist Thomas, to find the solution to Bessemer's phosphorus problems twenty years later. I have spoken about selectivity rules governing oxidation and deoxidation as if they were quite simple, but indeed they are not. In recent years a tremendous amount of research work has been done to put these on to a quantitative basis. Let me attempt to outline these rules in modern terms. Every element or compound, when present in a phase such as liquid metal, has a potential—that is, a " chemical potential." If an element likes to be in a particular phase—that is, it has an attraction for its intimate surroundings, its potential will be low. If, however, it has little liking for its surroundings, then its potential will be relatively high. This chemical potential can be measured by the vapour pressure p of the element or compound, and indeed is given by the quantity $RT \log p$. Scientists will recognise that this term has the dimensions of work or energy and they know that electrical potential can also be measured in units of work.

In all steelmaking systems we have to deal with three phases, a metal phase, a gaseous phase, and what is probably best simply called a slag phase, the latter consisting of a mixture of inorganic compounds such as silica, lime and iron oxide. An element such as oxygen or phosphorus can be present in all three phases and will have a potential in each of these depending on its concentration and on its attraction for the other elements and compounds which

are present. The potential of an element rises logarithmically as its concentration rises, and falls with an increase in attraction, as measured by the heat evolved on entering the phase.

The fundamental second law of thermodynamics tells us that an element can only move on its own from a phase of higher potential to one of lower potential. This is parallel to the simple axiom that water can run only down a hill. We have through this law a means of determining the direction of a chemical reaction. If we want to remove an element such as phosphorus from a metal phase, then we can either raise its potential in that phase or lower its potential in the other phases with which the metal is in contact. We can in fact raise the phosphorus potential in metals, but only very slightly, and, indeed, little use can be made of this effect. We know that in practice we cannot lower the potential of phosphorus in the gaseous phase sufficiently. Therefore, we are left with only one thing we can do, and that is to lower the phosphorus potential in the slag phase, and in this lies the secret of the Sidney Gilchrist Thomas process. In simpler language, we must not just attempt to push the phosphorus out of the iron, but we must draw it out by means of a slag which has a strong affinity either for phosphorus or for a compound of phosphorus such as P_2O_5. We do not know of any inorganic compounds that have a strong affinity for phosphorus in itself, but only of some which have this for the pentoxide. Strongly basic materials such as lime and magnesia have the affinity that we require.

But we can get P_2O_5 only by oxidation. This means that we need a high oxygen potential in the system in order to help the phosphorus in the metal to go over into the slag. This and a highly basic, but fluid, slag are the primary conditions for phosphorus removal. Under such conditions the ratio of the phosphorus concentration in the slag to that in the metal, known as the equilibrium partition ratio, can be got up as high as 500 (on a weight basis). At this equilibrium, the phosphorus potentials in the slag and metal are equal and the high relative concentration achieved in the slag is a consequence of the low energy level of the phosphorus atoms because of their high attraction towards their surroundings.

The chemistry of this sounds comparatively simple, but the practical problems facing Thomas of making a basic lining to a Bessemer converter were enormous. Nevertheless, he, with the help of his Welsh cousin, Percy Gilchrist, solved them, and the improved process swept the world in an even bigger way than the original Bessemer process. Indeed, it rather took the place of the former. It made possible the development of the great French and German iron and steel industries and the industries of Luxembourg and Belgium. It brought the Bessemer process into use with British home ores in the Cleveland and Midland areas and in South Wales, and went into many other parts of the world. To-day, over 60 per cent of French steel and one-half of the German is made by this process. This British invention allowed the industrial revolution to spread to countries in Europe and brought them into severe competition with this country.

Turning back to the chemistry of the process, we find that in the Thomas–Bessemer converter oxidation of the impurities takes place more or less in sequence. The oxygen of the air first attacks the silicon, which is always present to some extent in pig iron, and burns this to silica, the oxide of silicon. When this is mostly gone, the oxygen then attacks the carbon, and as the quantity present is rather large, some time is taken over this. When the carbon is mostly gone, the air will then oxidise the phosphorus if there is lime there to take up the phosphate produced. Some oxidation of iron also takes place during the phase of phosphorus removal.

Indeed, when one looks at the actual mechanism of this reaction, one sees that the oxygen molecules in the air entering the bottom of the molten-iron bath are much more likely to collide with iron atoms. These form iron oxide which subsequently reacts with the silicon and carbon while the bubbles rise. Oxidation of the phosphorus takes place when the iron oxide gets through to the lime to make a liquid slag on top of the bath, and this can occur only when very little carbon is left in the iron.

However, even after Thomas's success in the removal of phosphorus, the ups and downs of pneumatic processes were far from being at an end because a number of handicaps remained. The air blown through the converter contains 79 per cent of nitrogen, which has a considerable solubility in steel, especially when the carbon is reduced. (Carbon pushes up the potential of nitrogen in the metal phase, that is, opposes its entry.) This solubility is only partially achieved in practice, probably because nitrogen is very stable and only a small proportion of its molecules have the required energy of activation to dissolve in the iron. A certain amount of nitrogen in the steel does not matter for rails or tubes, but, unless special steps are taken to lower it, the steel will not be useful for some other purposes. For example, ships cannot be made indiscriminately of such steel, otherwise they might break. The weakness of Bessemer steel in this respect was found to be almost entirely absent in the open-hearth process invented by Siemens and Martin. It was some time before the reason for this difference was discovered: the nitrogen content of open-hearth steel was two to three times less than it was in Bessemer steel.

The open-hearth process also has one very important practical advantage, particularly in Great Britain, in that one can, along with pig iron, melt steel scrap very economically and make fresh good steel thereby. Therefore, even though the open-hearth process goes many times more slowly than the Bessemer process, it, nevertheless, can be more economical where steels are required for a wide variety of uses.

There is a third handicap to the Thomas and Bessemer processes. Enough heat must be generated to raise the temperature of the metal, melt the slag-forming materials and provide for the high thermal losses in the emitted gases and through the walls of the vessel. This and other operating factors put restrictions on the composition and temperature of the pig iron that can in practice be used; for example, the Thomas process requires an iron high in phosphorus and low in silicon, and the Bessemer process, iron low in phosphorus and high in silicon.

For these reasons, and despite its cheapness and simplicity, the Thomas process steadily gave way to the open-hearth, until to-day it represents less than 15 per cent of the world's production.

However, the decline is now being arrested, largely through developments made on the Continent. The first of these was the invention by Linde and Fränkl of the regenerator system of producing oxygen from air. This makes possible the large-scale or tonnage production of oxygen and reduces the cost of oxygen gas, but not liquid, by a factor of about five. This has led to a second recent Continental development, the use of this oxygen in the Thomas converter, either by enriching the air with oxygen or by using pure oxygen diluted with steam or with carbon dioxide. The second of these, the oxygen-steam process, was developed in Belgium and is making rapid headway there, and also in France and Germany. It is about to do so in this country; there will be two converter plants operating this process by the autumn of this year. In two or three years they will be joined by a third completely new plant.

The use of oxygen in the Thomas-Bessemer process removes most of the difficulties referred to above. First of all, the nitrogen content of the steel can be reduced to very low levels. More important, however, is that steelmakers are given a new degree of freedom; they are no longer bound to the 20·8 per cent oxygen in air but can change this at will. This allows scrap to be used and temperature-time paths to be followed which are best suited to the particular raw materials and final product. Oxygen brings back the small and frequent batch which is so much easier to integrate into the other continuous processes of a steel works. It brings its own problems, of course, but these will, I am sure, yield to the research effort now being put to them.

The Bessemer star is in the ascendant again; how far it will rise this time one cannot foretell. It seems likely that we will see a marked increase in the percentage of low-carbon steel made in this country by the process.

One cannot give a discourse on pneumatic steelmaking methods without bringing in a rather healthy young child which was born in Austria. The Thomas and Bessemer processes are almost too fast, and as a consequence it is difficult to control the composition to the required final specification. Part of the trouble is that such a process cannot be stopped without turning the whole vessel on its side, otherwise the steel would run back through the tuyeres at the bottom. It has always been attractive to steelmakers to have a process that can be carried out in a form of ladle, so that it can be stopped at will, samples can be taken and the necessary additions made. The Austrians have achieved this for mild steel by blowing a jet of oxygen down on to the surface of the metal contained in a pear-shaped vessel not unlike a Bessemer converter, but without, of course, the bottom air tuyeres. The impact of the jets sets up a vigorous chemical reaction and provides all the stirring that is necessary. In general, the chemistry of this process is very similar to that of the Thomas process, but with one surprising difference. As I said earlier, in the Thomas process the phosphorus is oxidised into the slag after the carbon is mostly gone. In this top-blowing process, however, the phosphorus comes out together with the carbon or indeed sometimes ahead of it. This has some metallurgical advantages and an interesting chemical explanation.

In top blowing, the ferric oxide formed by the action of the oxygen on the metal no longer has to survive an attack by silicon and carbon but immediately reacts with the lime present on the surface to form a reactive liquid. The slag has an oxygen potential much higher than that of the metal and, therefore, a reaction takes place between the two. As before, silicon is the first to be oxidised, but the oxidation of carbon is severely handicapped for a number of reasons. First of all, the solubility of carbon

in slag is effectively zero and the solubility of oxygen in the metal is low, so that carbon-oxygen atom collisions in either phase are infrequent. More important, however, is the fact that the product of combustion, carbon monoxide, has a very low solubility in both phases and effectively exists only as a gas. Because of the surface tension forces it is difficult for bubbles of gas to form in the metal phase or at the slag-metal interface, and because of the low solubility of carbon monoxide, very high supersaturations are necessary before nucleation of bubbles can occur. We have here in top blowing a case of a reaction being slowed down because of the difficulty the products have in getting away. Steelmakers will recognise that similar conditions apply in the open-hearth furnace where iron oxide is added to the slag, but these are not so pronounced as in top blowing.

In contrast with carbon, phosphorus has an easy road in reacting with slag. Practically every atom of phosphorus in the metal which arrives at the slag interface is drawn over into the latter phase by the affinity forces. To affect its oxidation it needs to give up electrons to the slag, and because of the high concentration of ferric iron, which can take up electrons to form ferrous iron, this is very easy.

We have seen earlier that Thomas, by introducing lime, made it possible to change the order of oxidation of elements and remove phosphorus before burning the iron. Now, with top blowing, one can make a second change of order and remove phosphorus before or in parallel with carbon. In comparison with bottom blowing the effect is very large at carbon contents above 0·1 per cent. At 1 per cent carbon the phosphorus partition ratios in top blowing are one thousand times greater than in bottom blowing.

Although this process is so far limited to low-phosphorus irons (below 0·2 per cent), where the slag volume is not too great for the oxygen jet to penetrate, it has a number of potential advantages in addition to those given above. Carbon steels can be made directly from medium-phosphorus iron without blowing the iron down to very low carbon levels and recarburising. Because phosphorus can be removed at lower temperatures where higher partition ratios obtain, the losses of iron to the slag need not be so high.

On its present basis, top blowing is making considerable progress in North America as well as in Europe, and some new developments to deal with the higher phosphorus irons in Great Britain are to be expected. These might well take the form of intermediate processes.

It is of interest to note that these processes of using steam and of top blowing were partly anticipated in Bessemer's patents nearly 100 years ago.

It would be fitting to conclude this address with a view of the future of pneumatic processes. We have seen that Bessemer's converter is expanding its field through tonnage oxygen and that a new top blowing process is growing up alongside it. But steelmaking will still depend on the intermediate production of the carbon alloy, pig iron, a product which is not only off the direct route from ore to steel, but is costly to make because of the special requirements of blast-furnaces.

It has been a desire of steelmakers for many generations to develop a direct steelmaking process, that is one which converts the ore to a low-carbon steel directly. A similar process, the sponge-iron process, has successfully operated in Sweden for some years. This uses carbon monoxide gas to reduce ore at temperatures below 1000 deg. Cent., where both the iron and the ore product are solid. More recently the Americans have developed the "H-iron process" (ref. 4), in which high-pressure hydrogen, produced by modern cheap methods from oil or hydro-carbon gas, is used to reduce powdered ore in a fluidised bed at temperatures near 500 deg. Cent. These processes cannot make steel because the impurities in the ore cannot be separated. They are important, however, because of their ability to produce for steel furnaces a good feed material if one starts with a high-grade ore.

We have seen that the speed of Bessemer's process came about through the dispersion of air bubbles in a liquid metal. Similar speed potentialities would exist if we reversed this system and dispersed small droplets of liquid ore in a high-temperature gas. Furthermore, if this gas could be maintained at a low oxygen potential, the ore droplets would be reduced to droplets of liquid metal plus slag. If the oxygen potential is controlled at the correct low value and lime is introduced for the slag, neither silicon, carbon nor phosphorus need come into the metal and thus the droplets would be a form of steel rather than pig iron. Finally, it would be necessary to precipitate the droplets out of the gas and allow the metal to separate from the slag by gravity and surface tension.

Laboratory experiments and technical developments in allied fields indicate that all the above are possible. Accordingly, the British Iron and Steel Research Association is actively engaged in developing such a process under the name "Cyclosteel." This is still in its very early stages and nothing like as advanced as Bessemer's process was 100 years ago. Furthermore, I suspect that even with all the modern techniques and resources at our disposal, it is going to take rather longer than it took Bessemer to get through the practical problems. It has, however, got away to a promising start and, in the preparatory stages, we have already made small quantities of very crude steel.

The process is best suited for an ore which is already in a finely divided state. Many sources already exist, particularly as products of ore-beneficiating processes. The ore is to be preheated, probably in a fluidised bed to a temperature just below where it becomes sticky, and then injected into the very hot reducing gas. The latter is to be produced by a fuel such as pulverised coal or atomised fuel oil with only sufficient air and oxygen partly to burn it. It is almost certainly necessary to use oxygen to maintain the necessary high temperature and low oxygen potential at one and the same time. From preliminary trials we know that the two reactions, ore plus carbon monoxide going to iron plus slag and carbon dioxide, and coal plus oxygen and carbon dioxide going to carbon monoxide, are fast with finely divided particles and only a short time in the reaction zone seems to be necessary.

The separation of the gas from the precipitated products will take place by gravity and cyclonic centrifugal action, and a settling chamber finally separates the iron from the slag.

The "Cyclosteel" process is in its very early stages and is only referred to here because of the way it fits into the evolution which began with Bessemer. Formidable technical obstacles stand in the way and will have to be surmounted. On the other hand, a method of making steel from powdered ore and coal is extremely attractive, especially as it avoids the sinter plant and the coke ovens and widens the range of fuels that could be used. It is unlikely to replace the blast-furnace, at least for many years, but if logic can be converted into practice it will take a place among pneumatic steelmaking processes.

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Oil and Industry

AT the Sheffield meeting of the British Association, Mr. A. C. Hartley delivered his presidential address to Section G (Engineering) on Thursday morning, August 30th. It very naturally dealt with "Oil and Industry," and for the most part gave information that was contained in the article entitled "Oil and Engineering," which Mr. Hartley contributed to the Centenary Number of THE ENGINEER, published on January 4, 1956.

In his address last week, Mr. Hartley observed that it had been said that the oil industry, if not yet the leading industry in the world, was very close to it. Until atomic energy was developed on a vast scale—and it was universally agreed that that could not happen for several decades—the world would remain critically dependent upon an abundant supply of oil products being readily available at the places and in the forms required. Industrial expansion could not otherwise be maintained, nor standards of living protected and improved. The magnitude of the task before the oil industry became clear when the full significance of the whole economic world activity was examined.

In this same context, Mr. Hartley observed that it was likely that atomic energy would be developed at least as quickly in Great Britain as anywhere else in the world, but the official estimate was that by 1975 it would only produce the equivalent of about 40,000,000 tons of coal. The present consumption of energy in Great Britain in all forms was the equivalent of about 250 million tons of coal a year, and the estimate was that that would have risen by 1975 to about 400 million coal tons. It appeared, therefore, Mr. Hartley said, that at the best atomic energy could not by that date provide more than 10 per cent of our needs, and the average for the world would be much lower. In fact, it seemed unlikely that atomic energy would be making as high a percentage contribution in 1975 as hydro-electricity was now making. A recent assessment of the free world's consumption of oil in 1955, Mr. Hartley added, was 695 million tons. It was estimated that that would have risen, even making full allowance for any possible contributions by coal and atomic energy, by about 70 per cent to 1200 million tons a year in ten years' time, and to at least 1600 million tons by 1975. This actual growth in the use of oil, Mr. Hartley remarked, was not due to its price, because, on a B.Th.U. basis, it was almost always more costly than coal. The growth in the use of oil was due to the fact that the industry had always been prepared to spend large sums of money in research and development into new processes in order to provide products best suited for each individual use.

S.B.A.C. Flying Display and Exhibition

No. 1

THE seventeenth display of the Society of British Aircraft Constructors commenced on Monday: to-day is the public premiere, and the exhibition is open on Saturday and Sunday at the Royal Aircraft Establishment, Farnborough, Hants.

Monday's flying display opened with a demonstration of air trooping by a "Beverley" C.1 of Blackburn and General Aircraft, Ltd. One hundred soldiers in battle order emplaned while the aircraft stood on the runway with the engines running. The big transport made a short flight, touched down and halted with reverse thrust, and unloaded the troops. The large clamshell doors into the freight hold of the "Beverley," from which single loads up to nearly 10 tons have been dropped by parachute, were not opened on this occasion, the riflemen entering one at a time through the small doors in each side of the hull.

The next aircraft to fly was a Short "Sperrin" four-engined bomber acting as a test bed for the de Havilland "Gyron," one of which was fitted in the lower bay of each nacelle; the aircraft made, as might be expected, a markedly abrupt disappearance into low cloud. Another power plant test bed followed—an English Electric "Canberra," modified to test the Napier "Scorpion" rocket engine, an angular protrusion at the rear of the bomb bay being the only external difference. As the bomber gathered speed, a puff of steam showed that one chamber had lit briefly; then another puff heralded the sustained use of a chamber to climb away from the airfield. The aircraft then flew past with two chambers burning, there being no smoke once the engine was warmed up, and climbed away in a slow roll with the rockets still in action.

Three Rolls-Royce projects were then demonstrated. The "Tyne" propeller turbine, credited on display with 4220 s.h.p. and 1235 lb thrust, 4695 e.h.p., for a net dry weight of 2023 lb, was installed in front of the nose of an Avro "Lincoln," and appeared much the same size as the 1760 h.p. "Merlin" circular nacelles. The exhaust duct below the fuselage was remarkably large—with a compression ratio of 13 : 1, the engine should have a favourable specific air consumption—the fuel consumption is 0·408 cruising at altitude. This trial installation, at least, has no propeller lock, for the propeller was tethered to a weight on the ground while the machine was parked. Taking off with all twenty propeller blades in action, the bomber returned with the piston engines stopped, flew past at a convincing speed, and climbed confidently away. Another engine for airline use, the "R.A.29" "Avon," is being tested in the "Canberra" that followed, both engines having been replaced.

Thrust reversers for jet engines demonstrated up to the present have fallen into two main families—"target" types, in which the jet from a normal nozzle is intercepted and driven sideways or forward, and "cascade" patterns, wherein the normal nozzle is wholly or partially closed and the direction of delivery reversed by a series of small aerofoils. A device of the latter description was demonstrated on a Hawker "Hunter" fighter, the cascades being fitted in the sides of the fuselage directly below the rudder. Such an aircraft is, of course, a favourable application for reverse thrust, since the air intakes are a long way forward and there is little risk of exhaust gas being inducted. The Rolls-Royce reverser consists of two doors pivoted at the top and bottom of the jet pipe and coming together to close it. When open, they lie in the walls of the pipe, forward of the pivots, and opposite the openings leading to the cascades. These are simple sets of strip metal blades, delivering the exhaust somewhat ahead of the beam; the panel in which they are mounted is surrounded by a "frill" of light metal through which cooling air can pass, to leave by an annular gap surrounding the jet pipe. The doors themselves are of sheet metal reinforced with top hat sections.

Novelty was introduced into the display of the rotating-wing aircraft by a Saunders-Roe "Skeeter" Mk. 6, with booster rockets at the tips of the rotor blades: the main components of the tip rocket system are seen in Figs. 5 and 7. This boost, with the same disposable load on the helicopter, raises the vertical rate of climb from 230ft per minute to 1400ft per minute, and reduces the minimum engine-off sinking speed from 1350ft per minute to 650ft per minute. The boost is regarded as valuable for operations involving vertical ascent in overload conditions, or taking off at extreme ambient temperature or altitude. The rockets are also of great virtue in emergencies, since lift without torque can be obtained in the case of a tail rotor failure, and safe descents can be made from heights inadequate for attaining autorotation after an engine cut. The tip thrust units, which are small enough to be easily held in one hand, consist of a catalyst chamber within which high test hydrogen peroxide is decomposed, an exhaust duct turning the flow from the radial to the tangential direction, and a de Laval nozzle in which the efflux is expanded to atmosphere. The makers of the tip thrust units, D. Napier and Son, Ltd., claim 25 lb thrust for each gallon per minute propellant consumption. The fuel system is as simple as a monopropellant engine can afford; the peroxide is carried in a circular tank above the rotor hub and fed to the blade tips by centrifugal force. An electric control system starts and stops the flow; it is anticipated that, to avoid the inconvenience of handling high test peroxide in service, the tanks will be supplied charged and returned to a depot when used. On Monday, a "Skeeter," hovering facing the wind, traced a couple of circles with steam at its tips and then climbed rapidly and vertically for some hundreds of feet. (The hover ceiling is raised from 1100ft to 8500ft by boosting.)

Another demonstration of the efficacy of tip jet propulsion was given by the Fairey

Fig. 2—The Bristol "Britannia" 301, prototype of the larger series with "Proteus" 755 engines

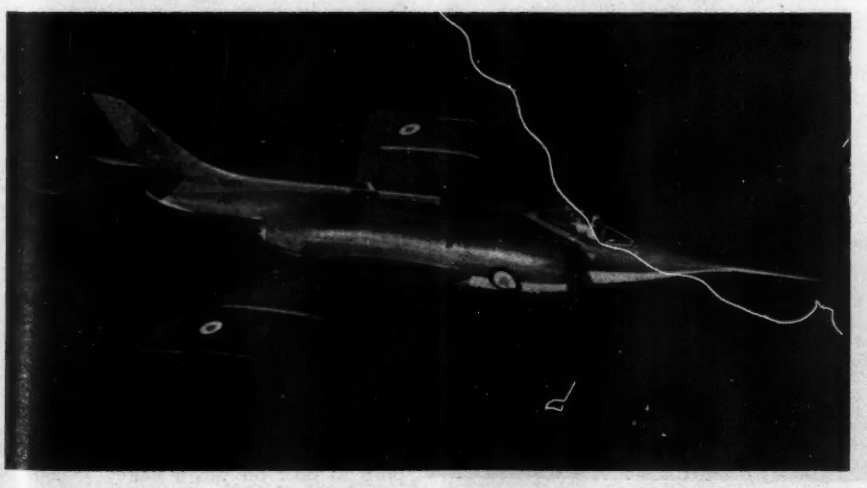


Fig. 1—The Vickers-Supermarine "N.113" naval strike aircraft. The leading edges of the wings droop and the flaps are blown

" Ultralight " helicopter, which claims to climb at 1350ft per minute. In action, it climbed quickly to about 800ft, went into autorotation, and descended vertically at great speed, checking with a run forward when it reached its ground cushion. Then, with the tip jets not burning fuel, and a swishing noise as loud as the previous roar, the helicopter flew back to the platform truck from which it had ascended and, with no ground crew attending, alighted on it. The precise handling of the aircraft is attributed to the fact that, to reduce the task normally confronting the helicopter pilot, power controls have been adopted, running from an engine-driven hydraulic pump, with an accumulator adequate for ten minutes' normal flying before reversion to manual operation.

Fig. 3—The Vickers " Viscount " V.802 on its maiden flight

On two occasions four Hawker " Hunters " were in the air together. The first was a demonstration of close-formation aerobatics by No. 43 Squadron, Royal Air Force, three of them with cartridge-link collectors under the fuselage. The second was when the brightly coloured T.7 joined three single-seat fighters, an F.4 with two " Fireflash " weapons aboard and F.6s with four 100-gallon tanks and twenty-four rockets respectively. The two-seater, besides making one of the fastest runs of the day, was the only machine to fly past inverted.

The Vickers-Supermarine N.113, seen in Fig. 1, did not land or even demonstrate its slow-flying ability. The " Swift " 7, however, took off on reheat, flew past fast, and made a landing that suggested a very satisfactory control system. This aircraft carried two Fairey " Fireflash" guided weapons. These are about 6in in diameter, and are propelled by two rather larger solid-propellant rockets with the exhaust nozzles near the rear and facing somewhat away from the projectile. An electric lead running back from the nose of one motor to the streamlined members joining it to the other suggests that, at all-burnt, an explosive charge separates the motors, the adjustable link joining them across the nose of the missile proper presumably being then free. The weapon then coasts to the target area : this is an attractive system for a beam riding missile, since there is no ionised rocket exhaust to obstruct transmissions from the carrier. However, it would seem that the ability of the " Fireflash " to engage targets flying above the defender must have been compromised, since the propellant motors are well in front of the missile's centre of gravity and, in all probability, the assembly accelerates straight ahead rather than under control. There are four wings and four control surfaces, symmetrically set in bisecting planes : the wings are sharp-edged and symmetrical in section, the control surfaces having very blunt trailing edges thinning towards the tips. On the " Swift," the upper rocket is carried on a forward-facing plunger, and the rear of the missile on a ball and socket with a sear to prevent the missile falling forward. The various electrical connections run into the tail of the weapon, which is occupied by the guidance gear.

Fig. 4—A new name on the programme was the " President," seen here as a six-seater executive aircraft

A junction box, presumably for final testing of the system, is carried on the pylon just above the store. The modifications to the " Swift " for carriage of guided weapons include a longer nose, which, to judge by the removable panels, contains the electrical equipment involved. The camera is still in a small bulge underneath ; the aircraft at Farnborough had a plain nose seemingly of metal, but Fig. 6 shows a different cap, which may be dielectric.

The ceiling on Monday being low, the Fairey " Delta " II could not demonstrate its unquestioned speed : two aircraft were present, and the one which flew was the holder of the Air Speed Record. The high rate of roll resulting from the low moment of inertia of the aircraft was demonstrated. The Static Exhibition includes the forward part of the fuselage of one of these aeroplanes, with the nose rocking up and down through 10 deg. The hinge axis is low in the section, and above it the two parts meet edge to edge and are locked up by two pins in bored lugs. Below the hinge there is a slight radial gap between nose and body which is taken up when the nose droops. At least in the display, the actuating mechanism is entirely below the pivot, with a very low mechanical advantage. Also on show is the exceedingly compact main leg assembly of the retracting undercarriage.

Fig. 5—The high test peroxide tank mounted above the rotor hub of the Saro " Skeeter "

On Monday, all three " V "-bombers flew. The Avro " Vulcan " made an impressive slow run up wind, and streamed a single large parachute on landing, the pilot 'chute and pack dangling from its crown, whereas those of the preceding delta had fallen away. The Vickers " Valiant " assisted its take-off with two De Havilland " Super Sprite " rockets. These were mounted beneath the jet engines, and the long orange exhaust flames, barred with shock waves, stretched back to pass under the lowered flaps between the two bends to clear the jet pipes. The self-contained rocket packs were not parachuted down on this occasion. The Handley Page " Victor " crescent-wing aircraft did not land.

The prototype " Viscount Major," seen in Fig. 3, was flown. The next turboprop to take off was a Fairey " Gannet " with an Armstrong Siddeley " Double Mamba " engine : it was noticeable that

very close synchronism between the propellers was maintained, even when the power was increased rapidly for take-off. The big three-seater landed again with the rear propeller stationary: it carried a variegated burden of violently-coloured stores, prominent under the wings being an air-sea rescue pack and a rotary disperser. The next performer was also a naval aircraft with weapons racked under the wings, De-icing is by rubber boots on wings and empennage, fluid on airscrews and windscreen. The "President" concluded the Flying Display on Monday, having demonstrated straight and level flight with one engine feathered and a baulked landing: during its demonstration there arrived the largest of passenger aircraft, the Bristol "Britannia" 301 (Fig. 2). With a fuselage 10ft 3in longer than the earlier models, the more powerful "300" series be noticed in Fig. 8 that each of the bifurcated exhaust ducts now ends in two circular passages, as this allows the jet pipes to be attached by clips and eases engine changes. The reduction gear annulus is not mechanically fixed to the casing, but floats in a hydraulic torque meter. This serves both to protect the engine from overload by overriding the fuel control, and to detect any transmission failure, in which case the engine is immediately shut

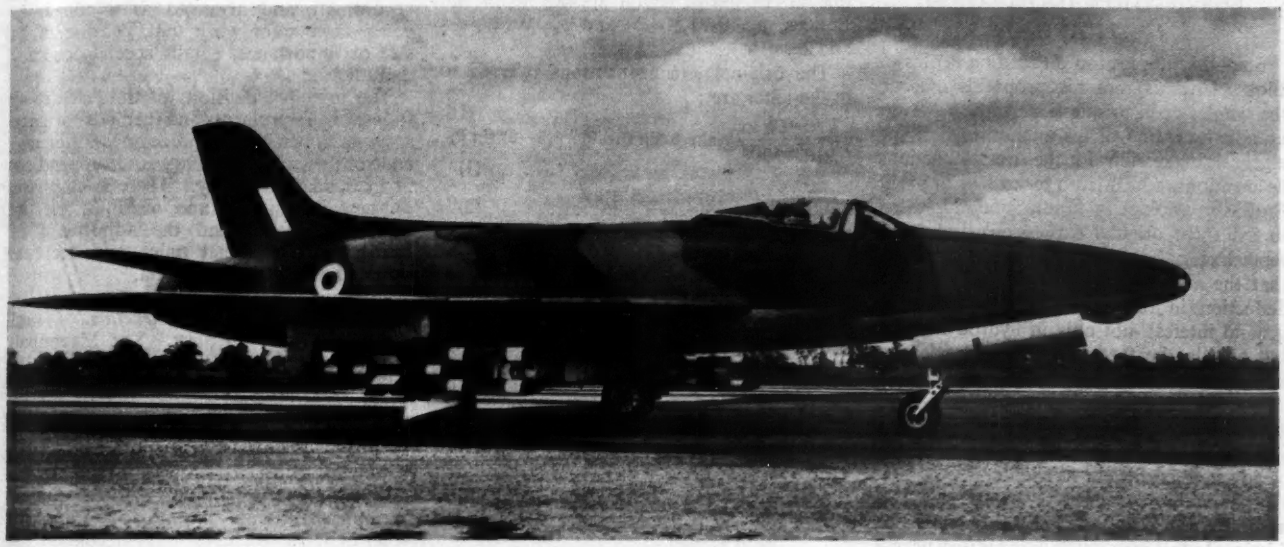


Fig. 6—The Supermarine "Swift" Mk. 7 carrying Fairey "Fireflash" guided missiles

a "Sea Hawk" built by Sir W. G. Armstrong Whitworth Aircraft, Ltd.

New in name if not appearance was the Hunting Percival "President." This machine is the culmination of the last five years' development of the Percival "Prince," a small air liner of classical conception. This aircraft is used by the R.A.F. as the "Pembroke" and by other European air forces for communications, training and ambulance work. The civil version has now been renamed, and appeared as an executive aircraft (Fig. 4) with seats for six, a toilet and galley facilities. The "President" can

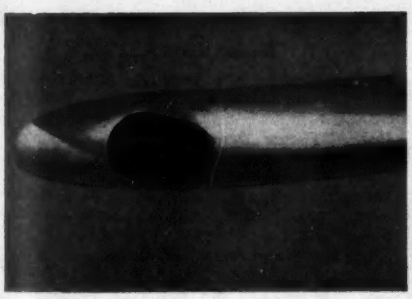


Fig. 7—The nozzle at the tip of the rotor blade is only about ¼in overall diameter

also be used for aerial survey and, using an automatic pilot—the Smith's S.E.P. 1 is standard—can provide a stable camera platform at over 20,000ft: the service ceiling is 24,000ft. The cabin is not, of course, pressurised, but heating and ventilating systems are standard. Fresh air is heated in the exhaust manifolds and passed to cabin, cockpit and nose baggage compartment. When the hot air supply is stopped by dumping through ducts in the inboard leading edge, cold ram air is fed into pipes which form the rails of the luggage racks. will include long range versions for transatlantic and transpacific routes.

Engines

Details are now available of the Napier "Gazelle" helicopter power unit. It will

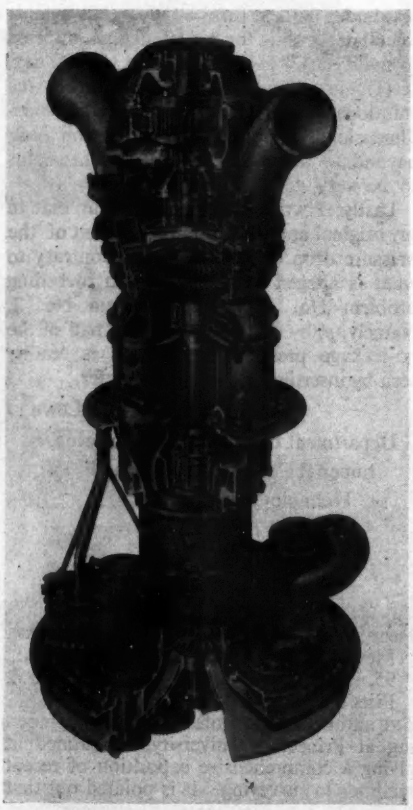


Fig. 8—A Napier "Gazelle" free turbine

down. Control of the engine is by a single lever selecting speed, compensation for intake temperature and pressure being automatic. During acceleration, a variable-datum turbine inlet temperature monitor prevents overfuelling, and the compressor inlet guide vane setting is also altered. The construction of the engine is generally on the lines associated with Napier engines, the eleven compressor stages having aluminium bronze blades, mounted on separate wheels of steel for stages 1 and 8 to 11, aluminium for the remainder. The six-flame-tube "cannular" chamber uses upstream injection, and each burner can be removed without the fuel system having to be reprimed. The turbine discs are "Rex" 448 and the blades "Nimonic" 100 and 90 respectively on the two stages of the compressor turbine, and "Nimonic" 90 on the power turbine. The auxiliaries comprise a centrifugal fan supplying air to cool the oil and ventilate the engine bay, an electric starter, fuel pump, revolutions-per-minute generator, centrifugal breather, and the pressure and scavenge oil pumps. All are located on the radial-flow air intake and gear driven; lubrication is dry sump, but hot oil is used to de-ice the air intake. The inlet guide vanes, however, can be heated by compressor bleed air, which is also used to cool the turbine discs and bearings. The output of the "Gazelle" N Ga 4, which weighs 900 lb, is 2000 h.p. for two and a half minutes in emergency (automatically selected when one engine in a twin installation fails), and 1575 h.p. for one hour, together with up to 300 lb jet thrust. At peak power, the specific fuel consumption is 0·635 lb per horsepower-hour, rising to 0·705 lb at the continuous rating of 1350 h.p. Continuous power can be taken at an output speed of 3300 r.p.m., but one hour and higher ratings at 3000 r.p.m. only. Compressor line speed is limited to 20,400 r.p.m.

(*To be continued*)

LETTERS AND LITERATURE

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

THEORY OF HYDRODYNAMIC LUBRICATION IN PARALLEL SLIDING

SIR,—My impression on reading Professor Blok's letter is that his proposals are, on the whole, open to question, with, however, notable exception of his method of deriving algebraic expressions for the stream-functions he mentions, which is no mean feat in itself. Professor Blok has kindly communicated to me these original expressions and I am reproducing them below. It is to be hoped that the author will soon be publishing his deduction in full, since the problem is of general interest, not only in hydrodynamics, but also in the theory of elasticity, electrostatics, electric current, heat transfer, &c.

Were it true that the steady-state film thickness in parallel sliding obeys expression (i) in Blok's letter it would follow that the steady-state coefficient of friction μ is no less than 1·255, as against $\mu=1\cdot047$ of my analysis. Namely, as I have shown, the frictional stress in parallel sliding is very nearly $\tau=\eta U/h$ and the 20 per cent decrease in h by Blok's (i) would only improve the accuracy of this expression for μ. Since $\mu=\tau/P$ by definition, the friction becomes an absolute constant and the reciprocal of the numerical coefficient in (i). Now, from what is known and generally agreed about the actual behaviour in sliding, if anything, one should expect $\mu\leqslant1$. Blok's high friction, which is without precedent, has made me feel that perhaps after all something is not right about the proposals. This clue has led me first of all to suspect Blok's expedient (*g*) of averaging the pressure along the $r=$constant arcs over the whole flow and using these averages rather than the actual pressure at the surfaces, at $\theta=0$ or $\theta=\beta$. After all, it is generally agreed that the pressure must not be averaged in the radial direction. Why, then, should it be permissible to average it within the same fluid in the circumferential direction, as if the surfaces were acted upon not by the pressure in the fluid where they contact it, but by the one composed from the actual values at distant points ?

By using the actual pressures (*b*) and (*e*) at the leading edge $\theta=\beta$, $r=h$, it is found $h=1\cdot070\eta U/P$, $\mu=0\cdot934$, at first sight seemingly very good values. It may well be so, but formally they cannot be right since they rely on the tacit assumption by (*e*) that the loss q of the fluid to the sink at the apex does not result in any drop of the pressure at the surfaces. Indeed, it is a matter of common experience that p_2 is never zero at the surfaces. It would appear, therefore, that (*d*) is not an exact solution, and this in its turn makes it questionable whether (*a*) is not spurious also. Incidentally, the middle sign in the bracketed part of (*a*) and (*b*) should be + to agree with (*c*), &c. A further clue to the effect that neither (*a*) nor (*d*) can be correct is obtained from the consideration of wide-angled cases, namely, $\beta=\pi$ (the razor-blade problem) and $\beta=2\pi$ (two coincident semi-planes). In both these cases p_1 by (*a*) is zero at the surfaces and p_2 by (*d*) is positive instead of being zero as at $\beta=\pi/2$ or being negative as it should. Because of p_1 being zero the load-carrying capacity due to the wedge action appears to be nil. Besides, $\overline{p_1}=0$ at $\beta=2\pi$ and $\overline{p_2}=0$ at $\beta=\pi$ and 2π.

The original stream-functions referred to in the letter are :

$$\psi_1=\frac{Ur}{\beta^2-\sin^2\beta}\{\theta\sin\beta\sin(\beta-\theta)-\beta(\beta-\theta)\sin\theta\} \quad . \quad . \quad . \quad . \quad (1)$$

$$\psi_2=\frac{2q\{\sin(\beta-2\theta)+2\theta\cos\beta\}}{2\cos\beta(2\beta-\sin2\beta)-\sin^2\beta} \quad . \quad . \quad . \quad . \quad (2)$$

the suffixes referring to the problem No. 1 and 2 respectively. These are believed to be exact solutions of Navier-Stokes's equation, since they satisfy the condition $\nabla^4\psi=0$ in plane polar co-ordinates. Differentiating (1) and (2), I find

$$u_1=\frac{U}{\beta^2-\sin^2\beta}\{\sin\beta[\sin(\beta-\theta)-\theta\cos(\beta-\theta)]+\beta[\sin\theta-(\beta-\theta)\cos\theta]\} \quad . \quad . \quad (3)$$

$$v_1=\frac{U}{\beta^2-\sin^2\beta}\{\theta\sin\beta\sin(\beta-\theta)-\beta(\beta-\theta)\sin\theta\} \quad . \quad . \quad . \quad . \quad (4)$$

$$u_2=\frac{8q}{r}\left\{\frac{\sin\theta\sin(\beta-\theta)}{\sin^2\beta-2\cos\beta(2\beta-\sin2\beta)}\right\} \quad . \quad . \quad (5)$$

$$v_2=0, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

where $u=\frac{1}{r}\frac{\partial\psi}{\partial\theta}$, $v=-\frac{\partial\psi}{\partial r}$, u and v being the radial and circumferential component of the velocity of flow. It is noteworthy that $u_1=0$ at just under 31 deg. for $\beta=90$ deg., as against 30 deg. in my original analysis, and just under 64 deg. for $\beta=180$ deg. as against my 60 deg., while for $\beta=360$ deg., u_1 appears to nullify at 78½ deg. as against my 120 deg. If (1) and (2) ultimately prove to be true solutions it would follow that my one-dimensional "polar" approximation fails beyond $\beta=180$ deg., but below this it remains to be very good throughout.

Lastly, I would like to point out that in my original analysis I do take account of the pressure drop due to the flux q, contrary to what is alleged in the paragraph preceding problem No. 1, and in problem No. 2. Namely, p_i by (19) is just about a half of the no-leakage pressure by (13), as is readily seen by inserting $\beta r=h$ into the latter.

W. LEWICKI

Department of Chemical Engineering,
Imperial College of Science and
Technology, London.
August 15th.

Literature

Surveying for Civil Engineers. By P. KISSAM. McGraw-Hill Publishing Company, Ltd., 95, Farringdon Street, London, E.C.4. Price 64s.

THE author, who is professor of civil engineering at Princeton University, has aimed at giving a comprehensive exposition of recent methods in surveying. It is pointed out that thorough, comprehensive surveys are essential, but expensive ; so it follows that the engineer must be familiar with the newest types of surveying equipment and techniques, as well as the theory of advanced applications of surveying, so that he can achieve the greatest economy in time and money. The contents of the book have been chosen accordingly and arranged as a course to cover surveys for work that, because of its size or importance, entails special accuracy and efficiency.

The principal divisions of the text are as follows :—Instruments and methods for large surveys ; operations ; procedures for precise control ; aerial mapping, and appendices in mathematical theory. There is emphasis on new instruments and methods, on the theory of errors, and the adjustment of triangulations, so that quick and accurate use can be made of survey data.

Route Surveys and Construction. Third edition. By H. RUBEY. The Macmillan Company (New York and London), 10, South Audley Street, London, W.1. Price 44s.

THIS book is of American origin, and is intended as a pocket reference book for survey and construction work, as well as for students. A broad approach to the subject is emphasised, with an approach to applications in most branches of civil engineering construction. The more notable changes in the new edition place emphasis on what the author calls "professional engineering, engineered-construction, professional management, contracting and practical photogrammetry."

Surveying Instruments and Methods for Surveys of Limited Extent. Second edition. By P. KISSAM. McGraw-Hill Publishing Company, Ltd., 95, Farringdon Street, London, E.C.4. Price 43s.

A SHORT, but vigorous, course in the fundamentals of surveying is given, covering the basic procedures that make up the bulk of surveying practice. The civil engineering applications are not dealt with. The new edition has been revised, and information added on new instruments.

Books Received

Matrix Calculus. By E. Bodewig. North-Holland Publishing Company, Amsterdam, P.O. Box 103. Price 53s.

Jig and Fixture Design. By P. S. Houghton. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 36s.

Principles of Physical Metallurgy. By M. C. Smith. Constable and Co., Ltd., 10, Orange Street, London, W.C.2. Price 50s.

ABACS or Nomograms. By A. Giet. Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 35s.

Induction Heating Practice. By D. Warburton-Brown. Odhams Press, Ltd., 96, Long Acre, London, W.C.2. Price 21s.

B.S.I. Annual Report, 1955–56. British Standards Institution, British Standards House, 2, Park Street, London, W.1. Price 5s.

Alloy Series in Physical Metallurgy. By M. C. Smith. Constable and Co., Ltd., 10, Orange Street, London, W.C.2. Price 50s.

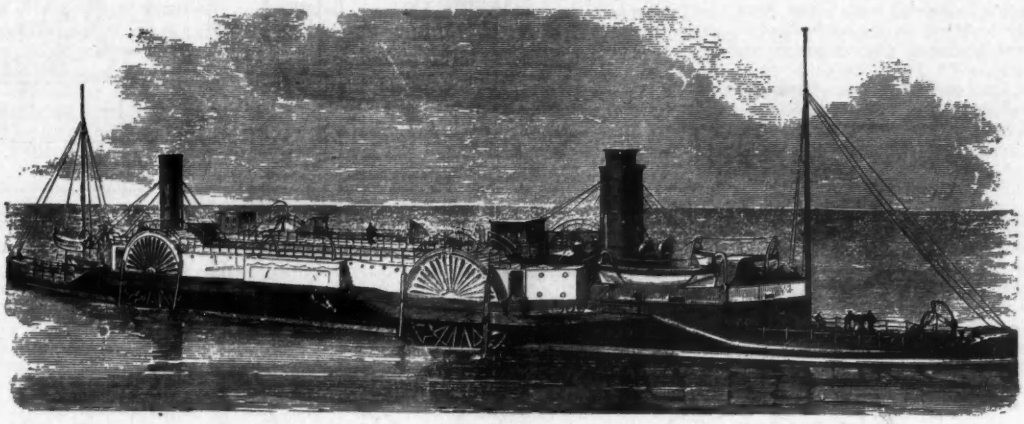
British Railways in Action. By O. S. Nock. Thomas Nelson and Sons, Ltd., Parkside Works, Edinburgh, 9. Price 25s.

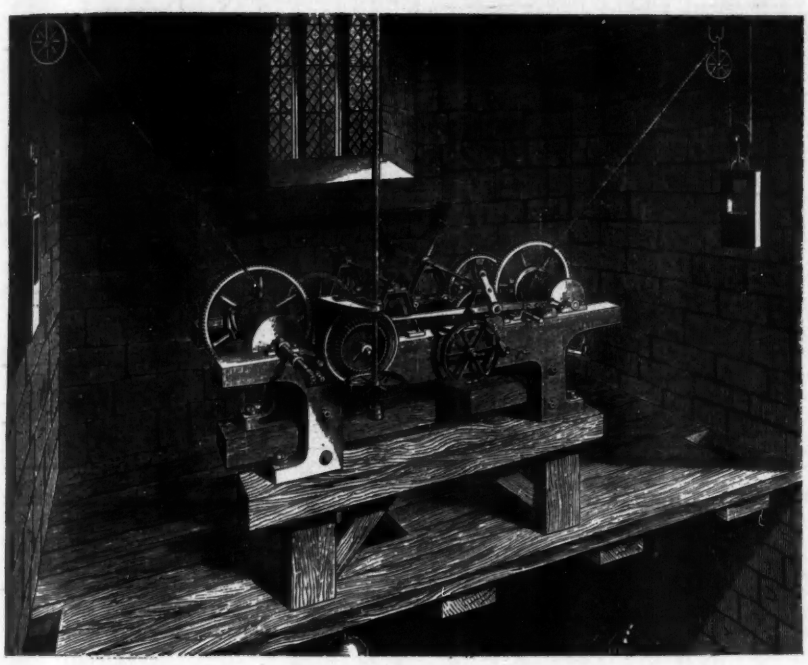
La Thermodynamique et le Théorème de L'Energie Utilisable. By R. Marchal. Dunod, 92, Rue Bonaparte (6e), Paris. Price 1580 francs.

Computers, Their Operation and Applications. By E. C. Berkeley and L. Wainwright. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 64s.

ENGRAVINGS OF 1875

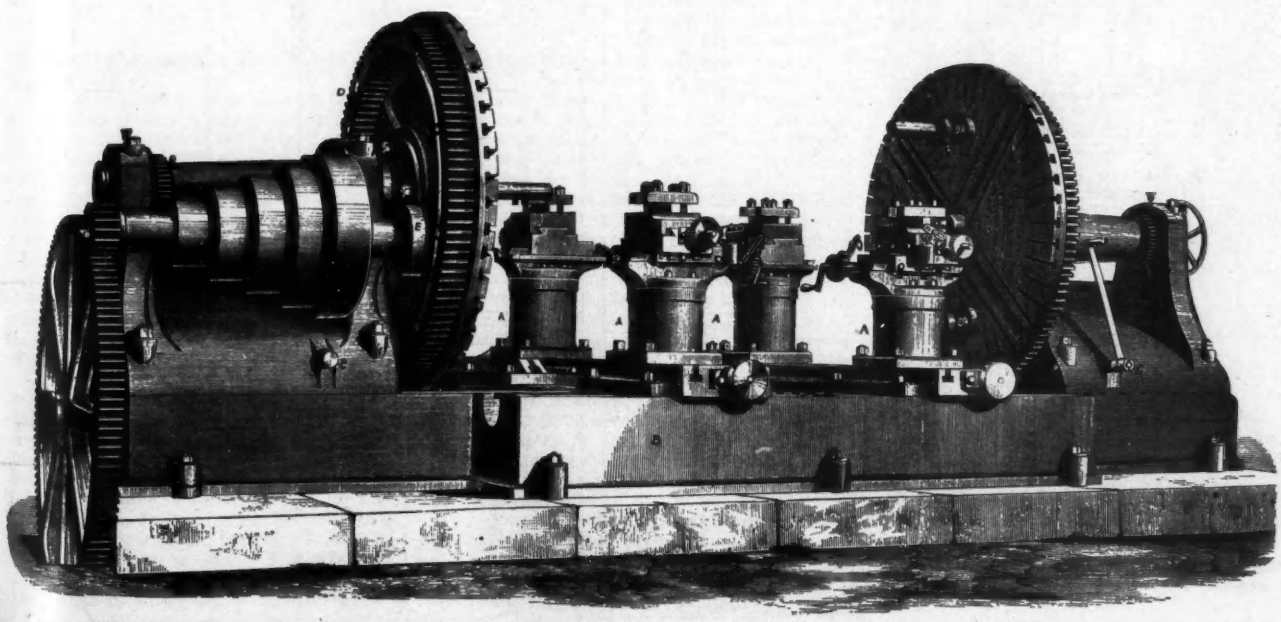
In our issue of May 14, 1875, we recorded that the long-expected trial trip of the steamship "Bessemer" had taken place a week earlier. This engraving (right) conveys "her general appearance," and our view was that she could "hardly be called handsome." Our description says: "the 'Bessemer' may be said to have practically no true keel at all, but she has deep bilge keels, which, though they do not obviate rolling, yet make the motion less disagreeable by reducing the rolling moment of the ship."



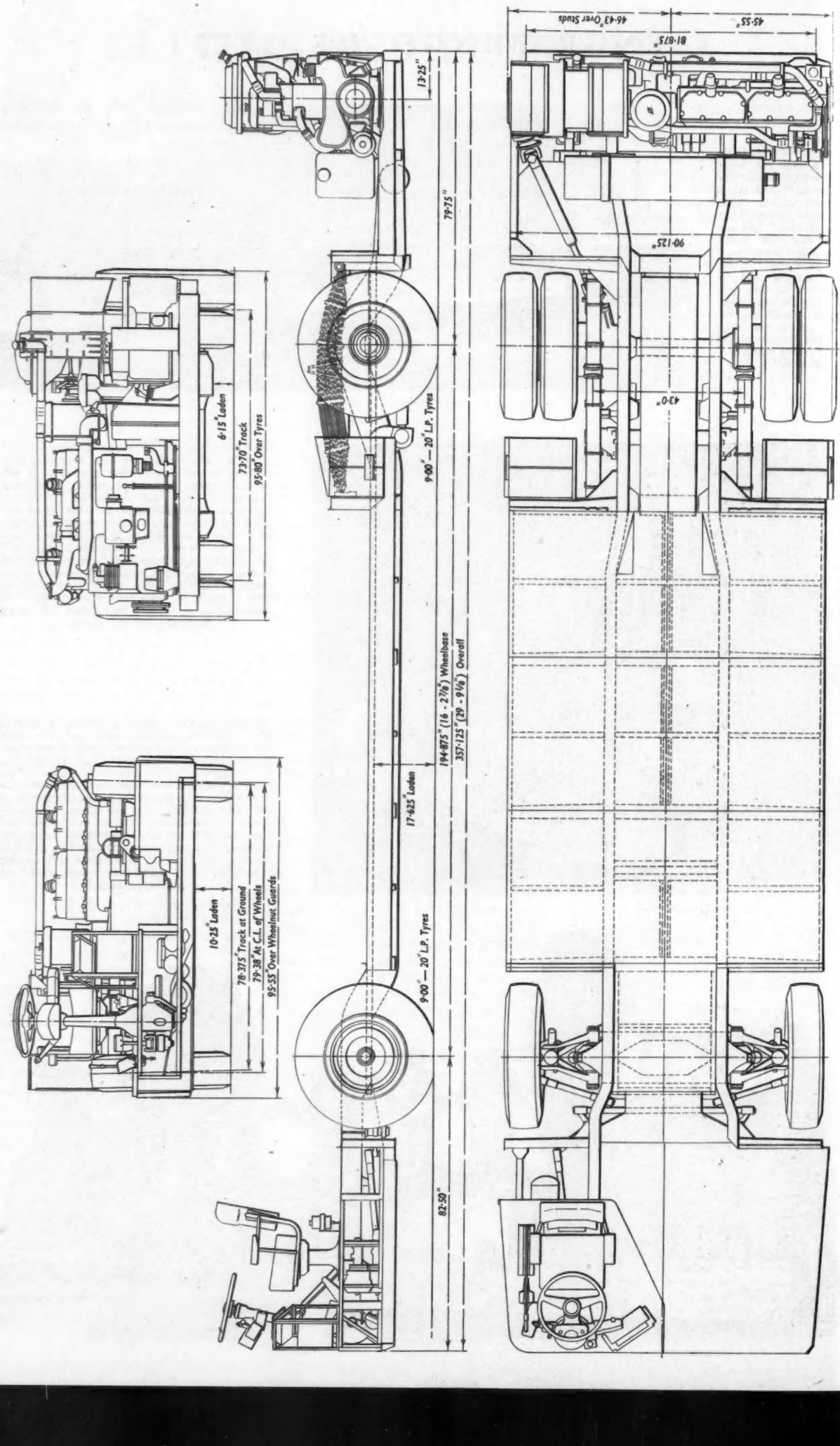


The mechanism of the "improved turret clock," which is shown in the left-hand engraving, was described in our issue of June 25, 1875. It was one of the large clocks manufactured by Bailey and Co., Albion Works, Salford, on the "lathe bed pattern in contradistinction to those which are called the 'cage' pattern, made by our forefathers out of strips of wrought iron bolted together to form a cage, and bushed with brass where requisite." Our description explains that "the wheels are of hard gun metal, engine cut, and the pinions are of hardened steel, the drums having a worm cut on them to enable the wire rope to coil freely." A number of these clocks, it was stated, were being fixed at home and abroad.

The engraving below, reproduced from our issue of May 7, 1875, illustrates a duplex wheel lathe which was installed in the Stratford works of the Great Eastern Railway. It was made by D. New and Co., of Nottingham. The description reads: "the lathe is arranged with four compound rests constructed to turn a pair of 6ft locomotive wheels on their axle, and for bossing and boring. The headstocks and rest-saddles are fitted on a massive bed plate, 18in deep and 23ft long over all, with planed surfaces. The face plates are carried on cast iron spindles, 14in diameter, in the front neck running in parallel bearings of cast iron, forming antifriction working surfaces."



GENERAL ARRANGEMENT OF "ATLANTEAN" 78-SEATER BUS



Rear-Engined Double-Decker Bus

The adoption of rear-engine mounting for a low-height, double-decker bus, together with the acute lock afforded by double-wishbone independent front suspension, has enabled seventy-eight passengers to be seated in a vehicle as light and as manœuvrable as the conventional double-decker.

THE traditional location of the engine at the front of a bus has been abandoned very generally in the case of the single-deck vehicle. An early example of this trend in the products of Leyland Motors, Ltd., is illustrated here, a rear-engined "Cub" with the power unit behind the last row of seats. This position has since been adopted by manufacturers in the U.S.A. and on the Continent, particularly in one-man vehicles where a front entrance is essential. When Leyland projected a double-decker of low overall height, the rear mounting was a logical choice, and the first experimental examples were built with the engine at the back of the loading platform. In order to have not less than the normal ease of boarding, this meant that the overall length of the power unit was somewhat less than the width of the vehicle, and a "Comet" engine was used. Further design studies showed that the passenger capacity of the vehicle could be so large that the conductor could not expeditiously control the platform and collect all the fares, and that a doorway at the front under the supervision of the driver was indicated. Both to weatherproof the interior and facilitate the driver's task, doors would then be necessary, but it was decided that these would be more than justified by the greatly reduced risk of accidents to passengers or intending passengers.

The rear-engine "Cub" was an early example of this engine installation

This change allowed the power unit to occupy the full width of the bus, and it was decided that, for use both at home and abroad, the new vehicle should have the larger 0.600 engine that was already widely employed on the "Titan" double-decker.

The final realisation of the design incorporates a system of heating and ventilating under the conductor's control that dispenses with opening windows. Built to the current British limitations of 30ft long and 8ft wide, the bus has thirty-four seats in the lower saloon and forty-four in the upper; it is called "Atlantean," from the Titan who carried the world.

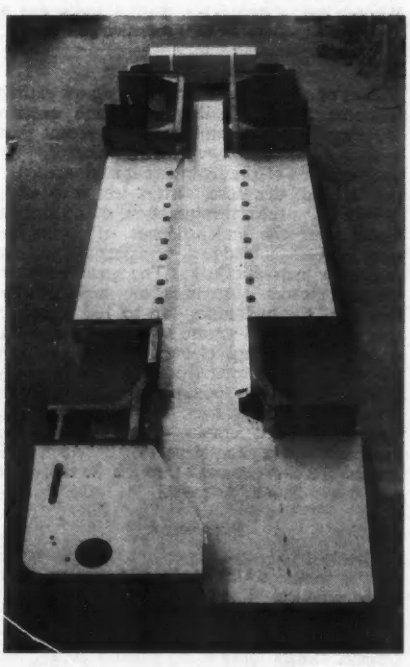
The vehicle is of semi-integral construction, the chassis being drivable without the body, but the body being built on to it and contributing to its stiffness; the body is added by Metropolitan-Cammell-Weymann, Ltd., but chassis alone may be available at a later date. The principal members of the frame are two longitudinals of 8½in by 3in channel pressed in ⅛in alloy steel; these spread the point loads of the suspension along the structure. Within the wheel base, these are joined by cross members, the upper edges of which are lowered for most of their length to give the desired height to the centre gangway. Opposite each cross member outriggers spring from the main spars; their tension flanges are united with those of the cross members by the light alloy floor plates. Further longitudinals join the ends of the outriggers; low as the frame is, safety rails are added below these members. As can be seen on page 338, the rear wheel boxes are essential parts of the structure, while the front suspension is carried on a broad fabricated transversal passing under the kick-up near the front of the frame.

The rearmost cross member is held by nuts and bolts and can be removed when the power unit is to be changed. The engine, clutch and transmission are assembled together and rest on two sandwich rubber mountings at the timing end and two rubber cone mountings near the gearbox. The complete unit can be removed in three-quarters of an hour; the makers consider this time satisfactory (see page 50 in our issue of July 13, 1956). The 9·8-litre engine gives up to 125 h.p. at 1800 r.p.m. to an automatic clutch. This component is similar in conception to the centrifugally loaded clutches used on some high-speed commercial engines, where bob weights on the operating arms acted to increase the load on the pressure plate with speed, so that the effort needed to disengage the clutch when idling could be reduced. The basic assembly is that of this engine's normal clutch, but a spring is added to drive each of the six withdrawal arms to the disengaged position. Bob weights cast on to the back of the arms overcome these springs under the influence of centrifugal force; the clutch commences to engage at 500 r.p.m. and is fully home at 800 r.p.m. The driven plate has a flexible centre and moulded liners $\frac{1}{16}$in thick; wear can be taken up in four stages. From the output shaft a train of gears runs upwards to the fan pulley; the cooling system is described below. Mounted on the rear of the engine are the fuel system and other ancillaries, including a Glacier oil centrifuge and a large oil bath air cleaner. The automotive rating of this engine is so low that the high temperature of the air inhaled has no adverse effect, and may even improve combustion. Excess fuel for starting may be selected only on the pump; no remote control is provided. The prototype vehicle uses a pneumatic governor, and has its silencer below the body discharging behind the offside rear wheel; later versions may have the exhaust led up to a silencer lying across the back of the upper deck, with the tail pipe emerging from the offside rear corner of the roof. The only accessories on the front of the engine are the dynamo, belt driven from the timing end of the crankshaft and accessible from beside the bus, and the starter motor, reached from within the lower saloon.

The gearbox is the "Pneumo-Cyclic" unit described in these pages on October 8, 1954. A pair of bevel gears then turn the drive 108 deg.; to lighten the duty of the propeller shaft, there is no reduction at this stage, but a hunting tooth is added to the driven wheel.

The rear axle is of the cranked double-reduction design associated with low-height buses, but with a notably long centre section as a result of the distinctive suspension. The primary stage of reduction is in a spiral bevel crown wheel and pinion which has a ratio of only 2·3 : 1, and it can be seen that its casing differs only in length from that at the nearside, which houses only the first helical gear of the second reduction stage. These latter gears are available in three ratios, giving overall reductions of 5·635, 4·91 and 4·31; the corresponding governed top speeds range from 34 to 45 m.p.h. The rear springs pass immediately above these reduction gears, and are attached to large pins mounted in spherical rubber bearings on the casings: these bushings take the weight of the vehicle and transmit side force, but allow the axle freedom in roll and pitch. The springs, which are mounted on rubber bushes, appear conventional, with an overload leaf; in fact, the free camber of individual leaves is so set that the springs have a rate variable between 1200 lb per inch in their equilibrium unladen atitude and 2000 lb per inch in the laden case. At the bottom of each axle casing, a second pair of rubber bushes carry the rear ends of two trailing links which are anchored in further rubber bushings at the ends of a tubular cross member. These links, built up of forgings bolted together, take no side force and are solely to transmit braking and driving reactions. It will be seen that each end of the axle is constrained by a Watts linkage, comprising the rear half of the spring and the trailing link; when the axle rolls, the linkage will attempt to twist the axle and bend the springs in plan view, but these errors are accommodated in the rubber joints. The links are so low that the tension in the spring, induced by the low-set anchorage, is not reduced to zero under any effort the engine can exert; this avoidance of stress reversal is expected to improve spring life.

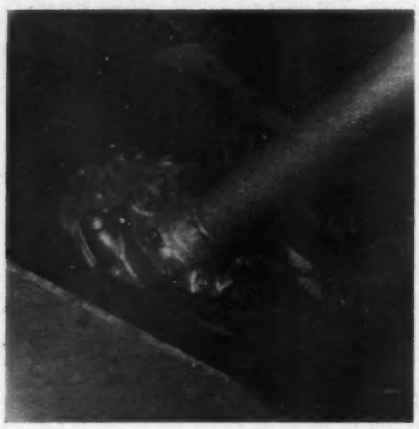
Front suspension is by unequal wishbones pivoted about longitudinal axes in rubber bushes. Telescopic hydraulic shock absorbers damp the movement of the lower wishbones. The wishbones are each built up of two forgings, and at the outer ends further bushes, rubber at the top and screwed at the bottom, carry the king pins. About these the axles swivel in oil lubricated bronze bushes, the weight of the vehicle being taken by the king pin on roller bearings. The steering arms project in front of the axles; bell cranks at each side give an exaggerated Ackermann geometry to the centre track rod to compensate for the convergence of the steering arms. The weight on the front wheels is low—all tyres are 9·00×20, although there is room in the wells for 10·00×20 equipment—



Frame of the "Atlantean," showing the absence of steps on the lower deck. The raised platform is for the driver

and it was, therefore, not considered necessary to standardise power steering. Springing at the front is by normal splined torsion bars, running through the pivots of the lower wishbones and reacting through short arms against adjustable abutments on one of the cross members. An approach to variable rate suspension is given by rubber blocks which are compressed as the wheel rises above the equilibrium position at half-load. The suspension is designed to give a frequency of 92 cycles per minute, irrespective of load. It will be noted that the roll axis is low at the front and high at the rear wheels; since the centre of gravity is not only low but also far back—fully laden, the back axle carries about 8 tons 11 cwt and the front 4 tons 2 cwt—the stability in roll would be expected to be great. This was confirmed convincingly by the experimental models above-mentioned, when they were in service with municipalities.

The braking system is unusual in its conception. Its energy is supplied by an engine-driven air compressor, which also charges to a lower pressure the gearbox air reservoir. A single air pipe runs the length of the chassis to the brake reservoir under the raised floor of the driver's compartment. The disadvantage of a delay in response usually associated with air brakes, which cannot be considered discounted by higher peak retardations, has been avoided by using the air to drive two hydraulic master cylinders, also under the cockpit, one for the front and one for the rear brakes. It has been found that



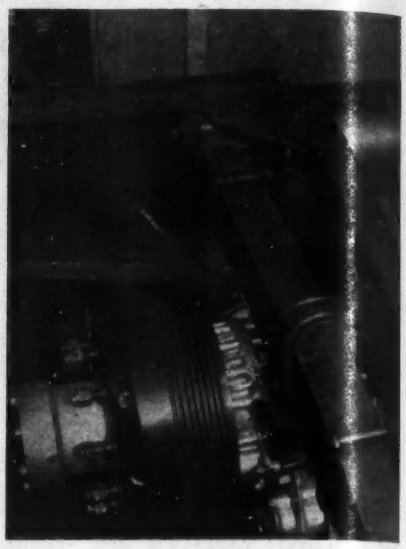
Nearside end of rear axle : the leaf spring can be seen passing above the final reduction gear casing

failures of air brake systems were almost entirely restricted to the flexible hoses and exposed components on the running gear, so that these failures should now have been eliminated. The flexible hoses of the hydraulic system are much smaller and, therefore, distort less with wheel movement ; their pressures are, of course, far higher, but the independence of front and rear systems introduces a safeguard in the case of a hydraulic leak. The great power of the air motors overcomes the high effective inertia of the hydraulics—up to 160 lb can be applied to each 36 square inch diaphragm—and a further advantage claimed is that since the air system is shielded from the slipstream the risk of freezing is minimised. A mechanical brake linkage runs back to the torsion tube joining the bell cranks through which the chassis-mounted rear slave cylinders act. All brakes are cam-actuated through Bendix levers with worm drive adjustment.

Bodywork

The control layout is perhaps the only system on the vehicle which attempts to follow established practice. The brakes are controlled by a pedal with 2½in effective travel on the right of the steering column, next to the accelerator treadle. Since there is no exhaust brake, considered more suitable for long fast descents than the incessant stops of urban service, the left foot operates nothing but a dip-switch. This arrangement for two-pedal control is not considered ideal, but was adopted to ease the conversion of drivers from vehicles with clutches. Actuation of the mechanical brake linkage by a lever at the driver's right hand was chosen in preference to the left foot pedal seen in France and the U.S.A., because the co-ordination of a start proved difficult ; it can readily be visualised that, if the vehicle rolled back, the correct action would be to press harder with the left foot, whereas a driver accustomed to a clutch would tend to raise that foot. Warning of lack of air pressure for the brakes, or coolant temperature in excess of 200 deg. Fah., is given to the driver by a buzzer ; two lights on a panel under the steering wheel show which warning is applicable. In between them is a speedometer ; it carries markings to show the speeds corresponding to 1600 r.p.m. in the indirect gears, this being the maximum engine speed consistent with best economy. No indication of clutch slip speed is given ; sufficient audible and tactile sensation reaches the driver for him to avoid such excessively low speeds. To the left of these indicators is the gear control, typical of electric selectors in having a miniature gate : there is a positive reverse stop. Optional is a system in which selection of fourth gives a fully automatic change to whatever forward gear is suitable for the speed of the vehicle. We may observe that, while inspecting the "Atlantean," we rode in another vehicle with the 0.680 engine of 150 h.p. and a "Pneumo-Cyclic" transmission ; while judgment on the part of the driver was needed to give a perfectly shockfree shift, changes against the engine torque, either driving or braking, were heard rather than felt. Under the driver's right hand are a time-cancelling switch for flashing turn indicators and the horn button. Low down on the left of the cockpit in front of the driver is a panel with the master switch and others for panel, side, head and fog lights, the discharge and oil pressure warning lights, and the engine start and stop buttons. The switches for lights in the passenger compartments are on a separate panel accessible to either driver or conductor. Another switch starts the electric windscreen wipers at the bottom of the nearside and the top of the offside windscreens ; an isolating switch for the former allows both to be parked at the ends of their arcs.

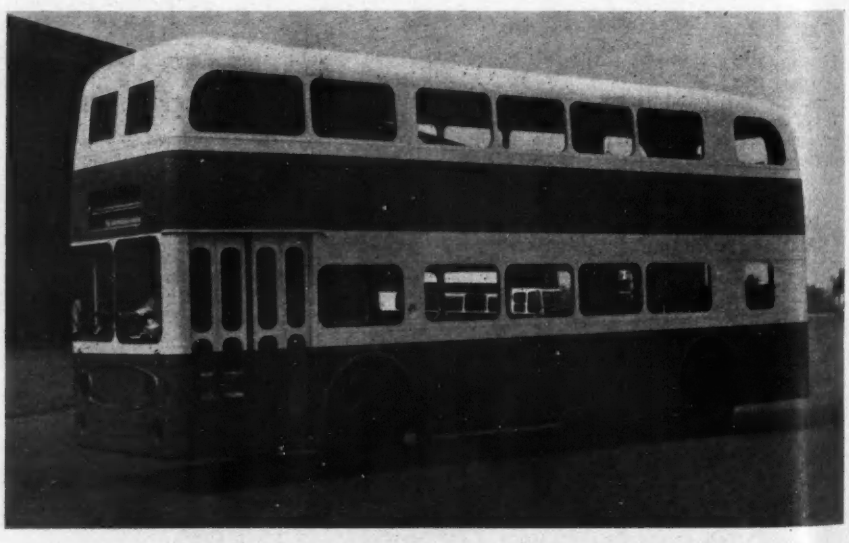
To the left of the driver, and accessible also to the conductor by reaching over the partition, is the lever controlling the pneumatic ram that operates, by a simple linkage on the floor of the upper saloon, the two jack-knife doors. These enclose a low platform from which a staircase with seven steps—one fewer than usual—leads from behind the driver to the upper deck. Behind this a slight slope blends into the centre gangway of the lower saloon. Opposite the staircase and the luggage locker under it, a seat above the nearside front wheel well faces inward ;



Offside rear brake drum and hub with propeller shaft in background

similar seats, set higher than the others, rest on the rear wheel boxes, and in each case there is a glass-windowed partition at the back end of the bench. With these exceptions all the seats face forward. The upper saloon has the centre gangway of a conventional bus, the seats being in pairs, apart from a single one opposite the head of the stairway and a full width bench at the back. The driver's bell is sounded by an electric contact in the form of a hollow rubber strip running the full length of the saloon roof. The floor of the upper deck, like that below, is panelled with light alloy sheets running transversely, but in this case the sheets are flat and stiffened by "top hat" stringers and lengths of "bowler hat" reinforcement. The skinning is attached by "pop" riveting. The side panels of the engine bay, and the small panel under the rear seat leading to the self-starter, are secured by manifold small screws, but on production vehicles they may be quickly detachable. In the front of the rear wheel boxes further detachable panels give access to the four 6V batteries, wired in series.

A final flourish of innovation is found in the heating and ventilating system. The fan belt drives, through a disc type coupling, a jack shaft leading over the transmission and through the radiator. Here, just within a grille in the offside of the body, the fan runs in a cast light



The prototype "Atlantean" is shown here partly completed. It can be seen that there is little obstruction to the driver's view over a wide angle

alloy shroud. The lower half of the radiator has an uninterrupted flow whenever the fan is running; this is only when the automatic clutch is engaged, so that the engine warms up rapidly if left to idle when cold. For use in hot climates this feature may be modified to avoid boiling when idling. The upper half of the radiator is cooled with air drawn, according to the position of a flap controlled by the conductor with a lever in the saloon, either or partly from within or without the body. When hot air is being extracted by the fan, fresh air enters the upper and lower saloons through grilles at the front of the bus. The lever has an alternative range of movement in which it controls also a flap on the delivery side of the upper radiator; thus air heated by engine coolant can be driven into the body, entering the upper saloon at floor level and the lower at roof level. Demisting of the windscreen is also effected by this supply. Since the fan is on the upstream side of the radiator, there is practically no possibility of fumes from the engine being induced into the system. The balance of the air finds its way out through the open bottom of the engine compartment, which may help to prevent moisture and dirt entering.

The standard M.C.W. body described and illustrated is 13ft 5in high in the unladen case and 13ft 2½in laden. The weight of the vehicle, unladen, is expected to be under 7 tons 15 cwt, so that despite its high carrying capacity its running costs should be no more than those of a conventional vehicle. The outermost point on the front of an "Atlantean" sweeps, on full lock, a radius of 31ft; this is no more than the corresponding figure for a 27ft long normal double-decker. The turning circle of the outside front wheel is markedly less than that of a forward-engine bus, about 27ft radius instead of 29½ft. The prototype, shown in the accompanying illustrations, will be seen at the Commercial Motor Show this month.

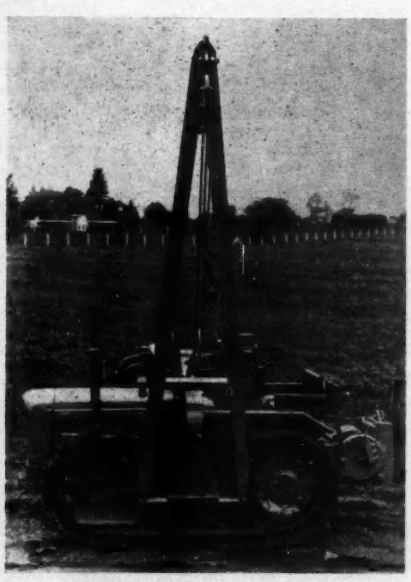
Industrial Equipment Display

In recent times, there has been increasing utilisation of agricultural tractors as power units for all kinds of industrial equipment. Tractors, and diesel-engined tractors especially, now have an established place in all sorts of public works contracting and building operations. This was emphasised last week by a working demonstration arranged by the Ford Motor Company, Ltd., at Dagenham, Essex. In this demonstration there were included over sixty machines, employing as their power units either the Fordson "Major" diesel tractor or a Ford industrial engine.

Visitors to this display of industrial equipment were first of all taken on a tour of the company's foundry and tractor assembly plant at Dagenham. They were also able to see something of the site development and constructional work that is now proceeding in connection with the Ford expansion programme. This programme includes the construction—which is now virtually completed—of a stores depot at Aveley, a few miles from Dagenham, and the building of a components factory at Basildon. At Dagenham, a new foundry building, covering 260,000 square feet, is due to be completed next April, and new roads, railway sidings and bridges are being built to improve the movement of traffic in and around the whole of the establishment. The work that is going on at Dagenham thus provided a suitable background for demonstrating a varied collection of contractors' plant. That collection included mobile cranes, loaders and shovels, compressors, dumpers, trench diggers and earth borers, road rollers, pumps and welding equipment.

Most of the equipment shown last week at Dagenham has already been fully described in these columns in the last two or three years, and in the space that is available for this present account we cannot refer, even briefly, to the many machines contributed by the forty firms which participated. We can do no more than mention one or two in order to convey some idea of the scope of the demonstration. Among the cranes, for example, there was the "County-Boughton" side boom equipment, which is made by T. T. Boughton and Sons, Ltd., Amersham Common, Bucks. The equipment, which is illustrated herewith, has been designed for use on pipe-laying contracts; it is fitted to a "County" industrial diesel crawler tractor. The drive is taken from the side power take-off shaft and transmitted by ¾in duplex chain to a 10in Rockford clutch and specially built gearbox. The gearbox has three functions—providing forward and reverse motions; two speeds of 60ft and 100ft per minute at an engine speed of 1400 r.p.m., and selection for either luffing or hoisting. The boom is 12ft long and at the apex there is a hole to permit the use of prop legs if required. The foot of the boom is 3ft wide and is hinged to the track frame of the tractor. The winch drums and transmission mechanism are mounted on a steel fabricated arch which spans the tractor from where the boom attaches, on the one side, to the track frame on the other side. There is provision on the winch side of the machine for a total of thirty-two counterweights of 104 lb each, giving a total weight of 3332 lb. The maximum lifting capacity of the crane, with the counterweights assembled, is 5 tons at 4ft radius and 2 tons at 10ft radius. Both the luffing and hoisting motions have double fall ropes, the hoisting rope being taken from the drum to a pulley fixed on the arch frame at the bottom of the boom. There is good manœuvrability as the side boom mechanism is operated by its own friction clutch control, which allows the hoisting and luffing motions to be made while the tractor is being driven along.

Earth boring machine powered by 40 b.h.p. diesel engine. The maximum auger speed is 120 r.p.m.



Tractor-operated side boom crane, with 12ft boom. It can lift 5 tons at 4ft and 2 tons at 10ft radius

Another item of equipment which we illustrate is an earth boring machine which took part in the demonstration. It is manufactured by Cheshire Engineering, Ltd., Camberley, Surrey, the power unit being either a Fordson "Major" 40 b.h.p. diesel or a Ford four-cylinder petrol engine. Our illustration shows the machine, with its diesel power pack, assembled on a truck; the borer is secured to the chassis frame by eight U bolts, and stabilising jacks are provided to protect the rear suspension from loads imposed during boring. The earth borer incorporates a double train of gears, controlled by two multiple-disc clutches and brakes. One train of gears rotates an auger and the other train drives the auger into the ground whilst it rotates. The boring head and intermediate cases are provided with power levelling mechanisms. Holes are bored in a series of stages, the auger being surfaced each time as soon as it is well covered with earth; when surfaced the auger is spun rapidly and the earth is flung off before lowering for the next stage. The augers available for normal terrain range from 9in to 36in in diameter, while for work in hard terrain there are augers of a double helix design. Alternative auger bars can be supplied, one for boring to a depth of 10ft 6in and the other to a depth of 20ft 6in. The maximum auger speed is 120 r.p.m.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

STEEL BILLETS, BLOOMS, BARS AND FORGINGS

No. 24, Part 4 : 1956. Price 3s. This revised standard was authorised by the Iron and Steel Industry Standards Committee and is part of a general revision of British Standards for railway materials. It dispenses with the previous practice of allotting "specification numbers" to the sections applying to individual materials, since it was considered that such materials could be adequately identified by the description of the product, the part of this Standard and the class number.

The new B.S. 24, Part 4, is divided into two sections: Section 1 deals with steel bars, billets, blooms and slabs for forging purposes, and specifies the quality of the material and the methods of manufacture, as well as the permissible rolling margins and the marking for identification purposes; Section 2, which covers steel forgings, forged bars and classes C and D rolled bars, specifies the quality of the material and identification, the selection of tests and the methods of tensile and cold bend tests. The forms of the tensile test pieces and the recommended heat-treatment for the finished forging are described in appendices.

Manchester Ship Canal Tug "Sabre"

THE first of four twin-screw tugs ordered from P. K. Harris (Shipbuilders), Ltd., by the Manchester Ship Canal Company has recently been delivered to her owners, and the three remaining to be completed are expected to take up towing duties by the end of the year. Burness, Corlett and Partners, Ltd., consulting naval architects, were responsible for the design of the vessels, which are of Hydroconic construction and meet the special towing requirements of the owners. The underwater lines, which have been developed on the Hydroconic principle, are stated to have given the tug outstanding manœuvring capabilities.

Canal tug "Sabre" in turning basin at Manchester

Our illustration shows the general appearance of the tug, which has a length overall of 97ft, a length between perpendiculars of 88ft, and a breadth moulded of 24ft 4in. One main item which can be noted in the illustration to be absent from the general profile is the funnel. This has been dispensed with in order to provide maximum all-round visibility for navigating purposes, especially when the vessel is carrying out the duties of the tug ahead. In place of the funnel the exhaust from the diesel main and auxiliary machinery is led into the base portions of two legs of the tripod mast. These have been designed to avoid creating any excessive back pressure and also to avoid exhaust fumes descending to the deck; to assist in the latter object, louvres have been fitted in the forward side of the exhaust outlet to deflect the gases upwards and help in their dispersal. Both trunks have been carefully insulated so that neither noise nor heat affect the accommodation.

Cabins and a separate mess room are provided for the master and the chief engineer and a separate room for the mate, together with a two-berth cabin with an adjacent mess room for the crew. Galley equipment includes an oil-fired cooking range and a refrigerator. Steering is effected by twin rudders operated by Donkin hydraulic-electric gear powered by an electrically driven pump, and a second motor and pump are installed for emergency purposes. Manœuvring trials indicated that when using both rudders and one engine the tug has a turning circle of one and a half to two lengths in diameter. With only one engine operating only 10 deg. of opposite helm was found to be required, and further tests showed that the tug could manœuvre astern using the rudders only. From a speed of 10 knots ahead the ship can gather astern way in twenty-five seconds.

To satisfy requirements for the tug to operate both ahead and astern, the propellers are of compromise design in order to provide adequate pull in either position. As fitted the propellers enable the tug to exert a pull of 17 tons when going ahead and 10 tons when pulling astern, while giving a light running speed of 10¼ knots. The two towing hooks have a safe working load of 20 tons and are fitted with a slipping arrangement which is operated from the bridge.

Propulsion is by means of two Ruston Mark 6VGBXM vertical, four-cycle, direct-injection diesel engines having six cylinders of 12·5in bore by 15in stroke. Each engine, which is uni-directional, has a continuous rating of 645 b.h.p. and a twelve-hour rating of 720 b.h.p., and delivers 603 s.h.p. to the propeller shaft. Cooling is by a closed fresh water system, which incorporates a 3kW heater for preheating the cooling water; provision is also made for heating the main engine water jackets with cooling water from the auxiliary engines. A centrifugal pump, belt driven from the main engine, circulates the lubricating oil and as standby there is a handstarted pump driven by a 4 h.p. electric motor. The engines are directly controlled from the bridge, but can be quickly disconnected in an emergency and be directly controlled by hand in the engine-room. There are no barred engine speeds, critical speeds having been overcome by careful gearbox design and the fitting of a torsional damper at the forward end of the engine crankshaft. To suit the exhaust arrangements the main engine silencers are located at the forward end of the engine-room and mounted one above the other, so that the port engine exhausts up the starboard leg and the starboard engine up the port leg of the tripod mast. Both silencers are specially insulated.

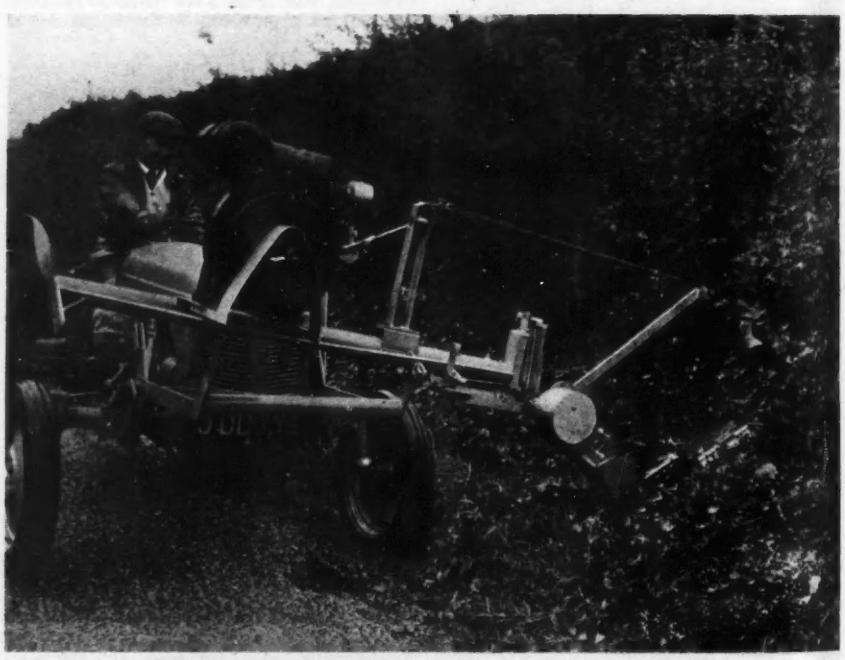
Each engine drives through a Hindmarch M.W.D. oil-operated reverse reduction gear, in which the normal 2 to 1 gear ratio has been modified to give a ratio of 2·408 to 1 ahead and 2·389 to 1 astern. This has been done so as to reduce the slow running of the propeller to 75 r.p.m. without introducing critical speeds. Each gearbox is equipped with two hydraulically operated brakes which are fitted on the clutch shaft and which automatically come into operation when the main engine telegraphs are in the "stop" position. The duty of the brakes is to prevent the propellers from turning when the tug is acting as astern tug and is being towed with engines stopped. Oil-operating pressure for the gearboxes is 50/60 lb per square inch and provision is made for an electrically driven gearbox lubricating oil pump to trip in, to restore the oil pressure, should it fall below 40 lb per square inch.

The auxiliary engines consist of two Lister "Freedom," Mark 6F.R.M. diesel engines, each driving a 25kW Laurence Scott generator, while provision is made for driving a Hamworthy air compressor and also a 36 tons per hour salvage and bilge pump. Each unit is carried on a single bed plate which is rubber mounted. Domestic hot water and hot water for radiators is supplied by an oil-fired boiler, which is fitted with an immersion heater for use when the radiators are not in use.

Front-Mounted Mowing Machine

AT a recent demonstration we were able to see the "Any Angle" tractor-mounted mower which has been specifically designed for the mowing of road verges inaccessible to the normal agricultural mower. The machine, which is made by Bomford Brothers, Ltd., Pitchill, Evesham, Worcestershire, is shown in our illustration. It can be fitted to a number of standard designs of tractor, and can readily be placed in position or dismantled. The cutter mechanism is carried in front so that the driver can attend at the same time to mowing and driving, and is independently powered by a 2 h.p. Petter engine, either petrol or diesel.

By inclining the cutter mechanism about a horizontal axis, from 90 deg. above the horizontal to 90 deg. below, banks or ditches of any slope can be dealt with. The tilting of the cutter is done by means of a hand-operated winch. The whole mechanism may be raised or lowered by hydraulically tilting the support brackets. In this manner, flat cuts may be taken on verges up to 4ft 6in high. In order to bridge roadside ditches, the cutter boom may be offset laterally. If the cutter bar hits an obstacle, it is protected by being able to swing back about a horizontal or vertical pivot. When this break-away occurs, the belts of the vee-belt drive from the engine come off and the cutter stops. The cutter bars are built in two versions: those of the standard agricultural design are either 5ft or 2ft 6in long and have an inner shoe for riding over accumulations of cut growth. The special bank bars are either 5ft or 3ft 3in long and are designed to cut over their whole length. They are intended for banks which spring up straight from the roadside.



Mower in operation. The wire cable-operated lever for inclining the cutter mechanism is clearly shown, also tilting bracket on which the mower may be raised or lowered as a whole

Industrial and Labour Notes

The Economic Situation

Last week, at a press conference, the Chancellor of the Exchequer, the Right Hon. Harold Macmillan, reviewed the economic situation. His statement commented in particular on the related subjects of profits, wages and prices.

In the course of his speech the Chancellor mentioned "four flat facts" about profits. First, he said, only a fifth of company incomes were distributed as dividends, and dividends, after tax, amounted to something like 10d. in the pound of wages and salaries after tax. Secondly, a quarter of profits went in company taxes and provided a large slice of the tax revenue. Thirdly, another 15 per cent of profits went to renew plant and machinery. Fourthly, the Chancellor continued, profits were the main source of savings for new investment and without them we should sink back, in a very few years, to the position of a hopelessly backward industrial nation. A fifth fact which the Chancellor said he would "add for good measure" was that between 1954 and 1955 wage and salary costs per unit of output rose 5 per cent, while profits per unit of output rose 1 per cent.

The Chancellor ended his statement by saying that the Government's appeal for responsible price policies had already been answered by the nationalised industries and many private employers. He asked the trade unions "to weigh very carefully the national consequences of any action they might now contemplate." The unions might have faults to find with the policies of management or of the Government, but they had the means to make their views known to both. Remembering their reputation for practical good sense, the Chancellor said he felt sure the unions would not do anything to undermine the economic strength on which their own future depended. There were, of course, he observed, other questions which arose. There was the problem of automation, on which the National Joint Advisory Council was already hard at work. There was also the problem of industrial mobility, the Chancellor remarked. Redundancy in certain sectors of industry would arise even in conditions of full employment, for without movement and elasticity there could not be a healthy industrial organism; if growth stopped, decay would set in.

The Trades Union Congress

The eighty-eighth Trades Union Congress is being held this week at Brighton. It began on Monday morning when Mr. W. B. Beard, delivered his presidential address. In that address, Mr. Beard said that Britain's economic position was undoubtedly the most important question facing everyone to-day. The need for increased productivity might seem paradoxical to those in industries where short time was being worked, but greater industrial efficiency was essential, and one way to that was a high level of investment in industry.

But, Mr. Beard continued, there appeared to be an unwillingness in some industries and firms to provide an adequate amount for that purpose. There was no direction of investment by the Government, or any evidence of compelling pressure on private industry to be up and doing in the markets of the world. Profits had been high, Mr. Beard commented, and the inflationary spiral had not been caused by the wages paid to workpeople, many of whom must find it difficult to make ends meet. The Government, he said, must be more resolute in tackling the question of investment. Investment policy, Mr. Beard went on, must bring with it full consultation with the trade unions, not only about greater productivity, but about its effects on employment, prices, profits, working conditions and the mobility of labour. If a worker had to change his job, Mr. Beard claimed, he should know why as far ahead as possible, and if a worker had to leave his firm he should, in some cases, have fair compensation in line with previous service. Moreover, a worker who had to learn a fresh job should be given the time and opportunity to train for it. Mr. Beard then spoke about employers who "were prone to look at twentieth-century conditions through nineteenth-century spectacles." He added that there were also workers who showed little interest in joint consultation or, indeed, in their jobs. Furthermore, Mr. Beard observed, the difficulties which arose from any quick impetus to greater productivity were apparent, especially where workers were likely to be displaced in large numbers. It was the duty of trade unions to deal with those difficulties; they must make sure that they developed joint consultation in its fullest sense.

As these notes go to press the Congress is debating economic affairs, including, of course, the subject of wages. At the beginning of this week, it became clear that the general council would not oppose a composite resolution asserting "the right of labour to bargain on equal terms with capital and to use its bargaining strength to protect the workers from the dislocations of an unplanned economy." The motion also called for the rejection of "proposals to recover control by wage restraint and by using the nationalised industries as a drag-anchor for the drifting national economy."

Wages

The Ministry of Labour has stated that changes in wage rates reported to have come into operation in the United Kingdom during July resulted in an aggregate increase of about £166,000 in the weekly full-time wages of 684,000 workpeople, and in a decrease of about £4000 for 170,000 workpeople. The decreases, which operated under sliding scale arrangements based on the index of retail prices, affected workers in metal manufacture, iron ore mines and limestone quarries in several areas and coke-oven workers. In the first seven months of this year, changes in wage rates resulted in an increase aggregating £5,902,800 in the weekly full-time wages of 11,587,000 workpeople. In the corresponding months of last year there was a net increase in the weekly full-time wages of 10,743,000 workpeople. At the end of July, the index of rates of wages (June, 1947=100) stood at 164 for all workers.

Last week it was announced that one of the wage claims put forward recently had been rejected. It was the claim for a 15 per cent increase submitted to the British Transport Commission by the Associated Society of Locomotive Engineers and Firemen, in respect of footplate men on British Railways. The British Transport Commission said that it could see no justification for conceding the demand. The next stage in the negotiating machinery is the Railway Staff National Council, which will, no doubt, now be called upon to consider the demand.

References to the Monopolies Commission

The Board of Trade has stated that, in accordance with the provisions of the Restrictive Practices Act, 1956, directions have been given to the Monopolies and Restrictive Practices Commission as to which of the existing references are to be continued. They are those on standard metal windows and doors; electronic valves and cathode-ray tubes; tea, and chemical fertilisers. The Commission's report on electronic valves and cathode-ray tubes is now to be a factual report only, and the reference on chemical fertilisers is being adapted to the Commission's new terms of reference under the Act; work on it will not be completed for some considerable time.

The Board says that the references which are being allowed to lapse are those on electrical street lighting equipment, steel frames for buildings, and electric batteries. These references were made during the summer of 1955, and work on them, which was not far advanced, was suspended when the Government's intentions concerning existing references were announced last March during the second reading debate on the Restrictive Trade Practices Bill. The general requirement on common prices and agreed tendering is also being allowed to lapse. Agreements embodying such practices will be subject to registration as from November 30th next, provided that Parliament approves the Registration of Restrictive Trading Agreements Order, 1956, which was made on August 2nd.

Industrial Disputes

According to the *Ministry of Labour Gazette*, the number of stoppages of work through industrial disputes in the United Kingdom, reported as beginning in July, was 152. There were fourteen other stoppages, reported before July, which were still in progress in the early part of that month. In the 166 stoppages, the number of workers directly and indirectly involved in July was 58,400, and in the aggregate 286,000 working days were lost. The stoppages included the strikes which occurred in the motor-car industry, and in some steel works where the maintenance workers carried their dispute beyond the ban on overtime. In the first seven months of this year, there were 1538 stoppages of work through disputes reported to the Ministry, involving 340,600 workers and resulting in the loss of 1,402,000 working days. In the comparable period of last year there were 1307 stoppages, involving 463,200 workers and causing a loss of 2,897,000 working days.

The Training of Supervisors

Recently, the Ministry of Labour has surveyed the progress that has been made in the training of supervisors in the two years that have elapsed since the publication of the report of a committee set up to inquire into the subject. It is stated that such statistics as are available and other information which has been received support the general impression that there is at present a much wider appreciation of the need for supervisory training and a growing acceptance of this training as an integral part of factory or office organisation.

The Ministry suggests that two years is probably too short a period in which to expect any substantial progress in raising the status of the supervisor. Managements generally accept the foreman as the "first line of management" and an effort has been made in some directions to re-examine his position and to give him increased responsibility. Senior management, the Ministry says, is increasingly aware of the problems involved, though there is sometimes rather less co-operation at the departmental level. An awareness of the problem, however, does not always result in action, and there are difficulties which undoubtedly limit the possibilities of providing effective training. Not least, the Ministry observes, is the problem, which is becoming more acute, of finding sufficiently experienced teaching staff or training officers.

Clyde Shipyard Strike

Last Friday evening about 5500 caulkers, burners, platers and welders employed in shipbuilding yards on the Clyde began a strike. The strike followed from the failure to reach agreement with the Clyde Shipbuilders' Association on a claim for a guaranteed weekly rate. The men's union has been pressing for guaranteed weekly rates of £13 5s. 6d. for platers, £14 7s. 6d. for burners and caulkers, and 6s. 6d. an hour for welders. The prevailing custom in these trades is piecework, a basic wage being supplemented by high bonus rates. At the time of going to press, there appears to have been no positive move towards a settlement of the dispute. Meanwhile, the effect of the strike is serious for Clyde shipbuilding; other categories of workers will inevitably be put out of employment on account of it.

Italian Oil and Gas Industry

By V. S. SWAMINATHAN, M.A., M.Sc. (Lond.)

No. II—(*Concluded from page* 314, *August* 31*st*)

Since the war there has been a rapid expansion in the Italian oil and gas industry, a natural gas grid has been constructed in the Po valley, oil fields have been opened up and refineries built at several places, including Genoa, Venice, Naples and Bari. The natural gas industry was described in the preceding article (No. I) and the oil industry is the subject of this article.

FOR all practical purposes the oil history of Italy dates from the geological investigations in the Po Valley by the Societa Petrolifera Italiana (S.P.I.), a subsidiary of Standard Oil (New Jersey), in 1926. They resulted in the discovery of oil at Fornovo Taro (Parma), and a daily output of 20 metric tons. Wells in this area were abandoned recently. The interest of foreign companies was dampened with the creation in 1953 of the E.N.I., which took over the capital assets of A.G.I.P. Also, by the still valid law of 1927, there was no guarantee, even outside the Po Valley, that a successful prospector would procure an exploitation concession. Attention was hence switched to Sicily, where a certain degree of regional autonomy allowed the granting of worthwhile terms to foreign capital. Exploration here by the American International Fuel and Petroleum Company, a subsidiary of Gulf Oil Corporation, led to a strike of 19 deg. A.P.I. crude oil at Ragusa. This well came in as a producer on November 8, 1953, and output is about 75,000 tons a year. In February, 1955, Petrosud (owned jointly by Montecatini and American International Fuel and Petroleum Company), discovered oil near Pescara, in the Abruzzi area of eastern Italy. Production here is around 100,000 tons a year of 34 deg. A.P.I. gravity oil. Oil in paying amounts was found at Vallecupa (Abruzzi) by the Italian E.N.I. later in the same year. Following these important finds on the Italian mainland, these wells had to be shut in pending the granting of an exploitation concession by the Italian Government. Even with the potential output from this mainland region, domestic production of crude petroleum will not, in the near future, greatly affect Italy's dependence on imports. Local output rose from 13,000 metric tons in 1938 to about 100,000 tons in 1954 ; the latter figure represents only 0·5 per cent of crude runs to domestic stills. In mid-1954 Italy, including Sicily, had twenty flowing and twelve shut-in wells ; its average daily production was 1459 barrels and cumulative output from the start just over 3,000,000 barrels. Sicily was not producing commercially at this time.

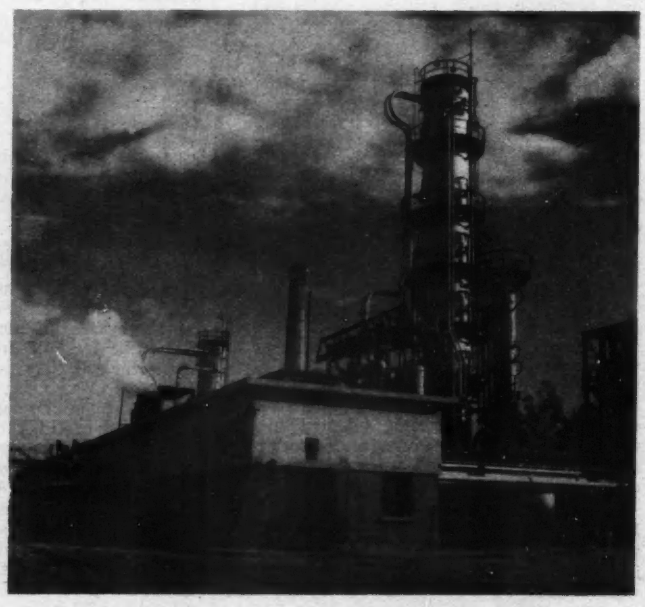
In 1953 the Italian refining industry processed approximately 13,000,000 metric tons of crude oil, compared with 2,120,000 tons in 1947 and 1,900,000 tons in 1938. In the last pre-war year it operated the following complete installations : A.N.I.C. (now Stanic) at Leghorn and Bari, with capacities of 360,000 and 300,000 tons, respectively; Aquilla, at Trieste, 300,000 tons ; Inpet, at La Spezia, 300,000 tons ; Socony - Vacuum, at Naples, 220,000 tons ; Romsa, at Fiume, 125,000 tons; Esso Standard, at Trieste, 90,000 tons, and A.G.I.P. (now I.R.O.M.), at Marghera, 375,000 tons. Including other atmospheric distillation units and minor plants the combined refining capacity was 2,260,000 tons.

From 1938 to 1945 the small new installations accounted for an additional 600,000-ton capacity. Subsequently these plants were enlarged : Inpet from 300,000 tons to 1,000,000 tons, Socony-Vacuum from 220,000 tons to 2,000,000 tons, and Aquila from 300,000 tons to 600,000 tons. After 1950 new units were constructed by several companies. The Leghorn refinery was rebuilt to 1,500,000-ton capacity, and throughputs of others were further enlarged. The geographical distribution of the production capacity of the Italian refineries based on Government permits is appended below :—

Region	Metric tons	Region	Metric tons
Piemonte	1,120,000	Tuscany ...	1,840,000
Lignaria	2,177,000	Lazio ...	240,000
Lombardia	2,232,000	Marche ...	500,000
Veneto and Venezia Guilia	2,255,000	Campania	2,800,000
Emilia and Romagna —	730,000 —	Puglie ... Sicily ...	1,300,000 1,000,000

In 1952 approximately 34 per cent of the capital invested in the refining sector was owned by British-Dutch and American concerns ; 31 per cent by joint Italian-foreign combines, and 35 per cent was indigenous. In terms of production capacity, foreign capital accounted for 5,954,000 tons, joint capital for 6,630,000 tons and local capital for 8,148,000 tons. In 1938 Italy imported crude oil, 1,474,000 tons, gasoline 99,000 tons, kerosine 52,000 tons, residual fuel oils 955,000 tons, lubricating oils 44,000 tons, totalling 2,624,000 tons, but since 1950 it has become an exporter of a range of finished petroleum products. In 1953 domestic production of crude oil was 80,000 tons, when 6,800,000 tons of petroleum were required for refining into finished products to satisfy the local market.

The current annual throughput capacity of the thirty-four Italian refineries is reckoned at 21,500,000 metric tons, nearly ten times the pre-war level, and very much in excess of 1944 domestic demand of around 8,000,000 tons. The larger units of the refining industry are mostly owned by the Italian affiliates of the major international oil companies, including Standard Oil Company (New Jersey), sharing ownership of Stanic Industria Petrolifera (S.p.A.) with the Italian Government Corporation A.N.I.C.; the Royal Dutch-Shell Group through Soc. per l'Industria Italiana del Petroleo (I.N.P.E.T.) and the British Petroleum Company, Ltd., with its 50–50 per cent partnership with A.G.I.P. in Industria Raffinazione Olii Minerali (I.R.O.M.). The Socony-Vacuum Oil Company Inc. operates a large refinery at Naples, and Caltex, in association with the Fiat organisation, owns the Soc. Azioni Raffinerie Padana Olii Minerali. In addition, the local refining industry includes a large number of generally smaller plants owned predominantly by Italian interests. Nearly a score of the Italian refineries have a capacity of less than 10,000 barrels a day.



Stanic refinery at Bari, with distillation tower in the foreground

Turning to individual installations, the Bari refinery was originally designed for the exclusive treatment of Albanian crude oil. Its supplies now come from the Middle East (Saudi Arabia and Kuwait), and smaller amounts from Venezuela and North America. Crude throughput figures in barrels per day for 1952–54 are given below :

1952	1953	1954
26,877	31,653	33,078

The modernised Bari refinery illustrated herewith has two atmospheric distillation units ; two thermal cracking plants ; two thermal reforming installations ; one two-stage atmospheric vacuum distillation unit ; one stabiliser ; a solvent extraction plant ; a gas recovery unit and a plant for finishing white products. It is linked to the port by a pipeline, is equipped with a steam-raising plant comprising four boilers, each producing steam at the rate of 45,000 lb per hour at 450 deg. Cent. and 580 lb per square inch, and has a combined storage capacity of 1,804,700 barrels. The terminal consists of one pier at which a " T2 " tanker and an 8000-ton tanker can dock together ; but a sea-line is under construction to enable larger tankers to discharge their cargoes offshore.

Stanic's refinery at Leghorn is designed to account for a complete range of products, and consists of one 13,000 barrels per day atmospheric distillation unit ; one two-stage, 29,000 barrels per day atmospheric-vacuum distillation plant ; two thermal reforming units, including a stabiliser ; a vacuum rerun unit ; a gas-recovery plant and light ends treatment facilities. The lubricating oil and wax-making plant embraces a " Duo-Sol " unit, a phenol treatment plant ; a propane dewaxing installation ; an acid-treatment plant ; a clay-contacting unit ; wax finishing and lubricating oil blending and packaging facilities. In 1954 the daily crude petroleum throughput averaged 32,416 barrels per day, yielding the following products :—Gasoline and turbo fuel, 6371 barrels per day ; other refined oils, 1613 barrels per day ; diesel fuel, 8074 barrels per day ; residual fuel oil, 10,708 barrels per day ; lubricating oils, 997 barrels per day ; bitumen, 702 barrels per day; liquefied petroleum gas, 527 barrels per day ; wax, 108 barrels per day, and other items, 1154 barrels per day. Two " T2 " tankers and one 2000-ton tanker can dock simultaneously at the terminal where crude can be discharged at 1200 metric tons an hour. A 20in pipeline conveys the crude to the refinery.

The important refinery of Socony-Vacuum Italiana S.p.A., with an annual capacity of 3,000,000 metric tons, is located at the outskirts of Naples. The photograph which we reproduce gives an aerial view of the refinery. Crude oil comes from the Middle East, and the movement of petroleum and products from this plant represents 65 per cent of the activity of the port of Naples. The largest tankers can discharge their cargo at two wharves, whence the crude is pumped to the refinery. Storage capacity for products is 457,755 cubic metres. The refinery's production in 1954 is given below (in metric tons) :—Crude throughput, 2,912,876 ; gasoline, 425,565 ; jet fuel, 169,526 ; kerosene, 218,562 ; gas oil, 465,851 ; lubricating oils and greases, 16,740 ; fuel oil, 1,505,182 ; asphalt, 1910, and liquefied petroleum gas, 12,969. Of these nearly 80 per

cent are exported to the Eastern Mediterranean countries and to Africa. This refinery is now equipped with three atmospheric distillation units with a combined capacity of 65,000 barrels per day, and one vacuum distillation plant, one 7000 barrels per day thermal reformer, one solutiser unit for gasoline cuts and one "Doctor" treating unit. A "Thermofor" catalytic cracking plant with a nominal rating of 15,000 barrels per day and a catalytic polymerisation unit (employing the phosphoric acid process) licensed by Standard Oil of California, Hydrocarbon Research were recently commissioned.

Status of Major Italian Refineries as at November 30, 1954

Region and refinery location	Processing capacity as per Government permit (1000 metric tons)	Authorised capacity + 30 per cent reserve (1000 metric tons)	Distillation capacity (1000 metric tons/year)	Reforming (Metric tons a day)	Cracking	
					Thermal (Metric tons a day)	Catalytic (Metric tons a day)
Piemonte, Sarpom (*a*), Novara ...	1,000	1,300	900	666	—	—
Liguria, Inpet La Spezia	1,500	1,950	1,610	360	—	—
Lombardia, Condor Rho	1,400	1,820	1,980	—	—	2,000
Veneto and Venezia, Aquila (*b*), Trieste	900	1,170	900	370	—	—
Veneto and Venezia, Irom Porto Marghera	1,100	1,430	1,470	900	100	100
Emilia - Romagna, Sarom (*c*), Ravenna	540	702	460	300	—	—
Toscana, Stanic Livorno	1,500	1,950	1,700	450	—	—
Campania, Socony - Vacuum Napoli	2,800	3,640	3,330	850	—	1,800
Puglie, Stanic (*d*), Bari	1,400	1,820	1,770	560	—	—
Sicilia, Ra. Si. O.M. Augusta ...	1,700	2,210	450	312	530	—
Total (including minor refineries)	17,189	22,346	18,320	7,303	1,430	4,580

(*a*) To build catalytic cracking plant.
(*b*) To increase capacity and to build catalytic cracking plant.
(*c*) To build lubricating oil plant.
(*d*) To increase capacity; allowance was made for a 1000-ton daily cracking capacity, the product being used for distillation.

Installations for the manufacture of lubricating oils include furfural extraction, dewaxing (M.E.K.), filtration and compounding. There is also a plant for producing greases and special products.

The I.R.O.M. (Industria Raffinazione Olii Minerali) Company set up in 1948, jointly by the Anglo-Iranian Oil Company (now British Petroleum Company), and A.G.I.P., operates the Porto Marghera refinery of which we give a general view at Venice. It has one two-stage and one three-stage distillation units, and there are two thermal reformers—the first a Kellogg plant of 6000 barrels per day capacity, and the second a converted Dubbs cracker of 1750 barrels per day. A Universal Oil Products (U.O.P.) catalytic polymerisation plant (1400 barrels per day nominal capacity) for producing high-grade gasoline component was commissioned in August, 1953. This is allied with the new Kellogg reformer. There is, moreover, a 25,000 metric tons a year lubricating oil acid and clay treatment unit, two solutiser units, each of 4000 barrels per day, and a kerosine treatment unit of 2500 barrels per day. The 1954 throughput of this refinery was 1,519,000 long tons. To be commissioned this year is a U.O.P. platformer with a nominal rating of 2000 barrels per day, the first in Italy. Pipelines take products to the coastal depots of A.G.I.P., Shell and Esso Standard Italiana, and are then distributed there by road and rail.

The Condor refinery at Rho, near Milan, is of particular interest, since it is one of the installations built away from deep-water ports. The major units are a 45,000 barrels per day topping plant and a 15,000 barrels per day T. C. C. Socony-Vacuum catalytic cracking plant. In line with marked needs in the area particular attention has been paid to the production of liquefied petroleum gases. In the near future the highly purified streams of propane and butane from the gas separation plant may serve as raw materials for manufacturing petrochemicals. The company operating the refinery is an independent one, financed by local capital and manned by Italians.

A pipeline 90 miles long, served by a pumping station at Fegino, carries the crude oil from the storage installation at Genoa over the Apennines via the Bocchetta Pass. The oil dock at Genoa has two piers with a 40ft depth of water and can berth two large tankers simultaneously. Three rectangular pontoons form the boom for closing the dock entrance, and they are available for the isolation of other sections of the port, should any leakage of oil occur during the unloading of tankers. Two 16in pipelines connect the dock to the storage depot, which has a capacity of 500,000 barrels.

La Spezia owes its importance largely to the Shell Italiana Company, some 75 per cent of the port's activities being accounted for by the Shell "Inpet" refinery, which has a crude distillation capacity of 5100 metric tons per stream day. This refinery uses Iraq and Venezuelan crudes, piped from the marine terminal, where three berths accommodate respectively tankers of 20,000 deadweight tons, 12,000 deadweight tons, and 1000 deadweight tons; a new mole, completed in June, 1955, permits two 45,000 tons deadweight tankers to unload at an hourly rate of 2500 metric tons. Tank capacity at Inpet is undergoing expansion, and two new tanks of 15,000 cubic metres each will raise the total capacity to 230,000 cubic metres.

Equipment at this Shell installation includes an atmospheric distillation plant; two topping units with a combined capacity of 5000 metric tons a day; a thermal reformer, 360 tons a day; and a high vacuum plant of 550 tons capacity. Product lines for motor spirit, kerosene, gas oil and fuel oil connect the refinery with the port.

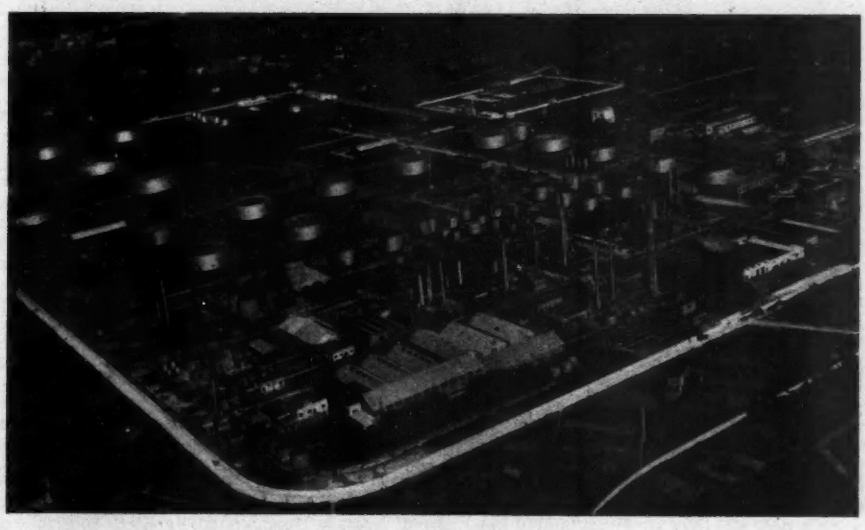
Aquila S.A. was set up in 1934 and the refinery at Trieste was commissioned three years later. This installation was virtually destroyed during the last war, but has been rebuilt enlarged and now has an annual distillation capacity of 1,000,000 metric tons. Reconstruction was made possible by E.C.A. credits, and the new plant includes a furfural extraction plant combined with units for propane de-asphalting and dewaxing by a mixture of M.E.K. and toluol. When the refinery resumed operation in 1947 the crude oil supply had to be obtained from the Middle East instead of the United States, and this entailed a reorganisation of plant, including the installation of a U.O.P. thermal reformer, and a solutiser plant, in which the mercaptans are extracted from the motor spirit cuts. In 1954 a "Thermofor" catalytic cracker (T.C.C.) was added, and these three units give a wide flexibility and a high octane rating over the entire range of motor spirits. There is also a substantial throughput of liquefied petroleum gas. Aquila is now a manufacturer of bitumen and a range of by-products from aromatic solvents to special waxes has been developed.

Sicily, first to produce crude oil in commercial quantities, has a modern refinery at Augusta on the east coast. Set up in 1948, the Raffinerie Siciliana Olii Minerali (R.A.S.I.O.M.) acquired a 10,000 barrels per day topping and cracking plant in Longview, Texas, and this installation was dismantled and shipped across the Atlantic to Augusta where it was re-erected and brought on stream in 1950. Since then, by further additions, the refinery's annual throughput has been raised to 2,200,000 metric tons. The Augusta refinery is equipped with three atmospheric distillation plants serving different ends. Thus T1 of 10,000 barrels per day capacity is a combined topping and Dubbs thermal cracking unit; T2, capacity 25,000 barrels per day, is equipped with a preflash unit, in which the lighter fractions are separated from the charging stock and transmitted in vapour phase direct to the principal distillation column; and T3, of 5000 barrels per day capacity, treats crude best suited for the manufacture of lubricating oils and bitumen. Plants for catalytic desulphurisation, 3000 barrels per day capacity, using Cyclocel as a catalyst and catalyst regeneration, caustic washing and stabilisation sum up the major Augusta units. A catalytic polymerisation plant of 3500 barrels per day capacity has been completed recently.

The chemical refining section consists of two caustic washing plants—one batch and the other continuous—two sodium plumbite "Doctor" sweetening plants for topped, cracked and reformed gasolines; one plant for washing with hypochlorite and clay; and two units for the centrifugal separation of gasoline from plumbite sludge. Production of refined products at and exports from the refinery are given below.

	Production (In metric tons)	Exports (In metric tons)
Motor spirit	209,834	149,072
Jet fuel	41,062	33,493
White spirit	3,026	3,082
Kerosene	51,973	34,928
Gas oil and marine diesel oil ...	317,408	193,111
Fuel oil	640,709	251,705
Bitumen	31,491	16,886
Liquefied petroleum gas	15,291	—
	1,310,794	682,277

The figures below give Italy's production and



Aerial view of the Socony Vacuum Italiana refinery at Naples

consumption of major petroleum products for selected years in 1000 metric tons :—

Products	1954	1952	1950	1938
	Production			
Motor spirit	2805	1721	984	422
Kerosine*	1028	614	299	154
Gas oil	3156	1762	1040	261
Fuel oil	7221	4527	2428	461
Lubricating oil	131	96	58	—
	Consumption			
Motor spirit	1170	900	655	458
Kerosine*	200	206	185	184
Gas oil	1417	1065	725	261
Fuel oil	4600	3075	2300	1364
Lubricating oil	166	134	120	No details

* Including white spirit.

In 1953 the country's crude oil imports were valued at 165,000 million lire, or 11 per cent of the total value of imports. Italy's exports of petroleum products in recent years are indicated below in 1000 metric tons :

Products	1954	1952	1950
Motor spirit	1532	850	282
Kerosine	858	374	125
Gas oil	1566	723	198
Fuel oil	2068	1778	343
Lubricating oil	8	5	12
Bitumen	76	33	9

These were valued at 89,200 million lire in 1954, or nearly 10 per cent of the total value of the country's exports. The partial closing of the Haifa refinery in Israel, and the subsequent shortage of refining capacity stemming from the shut-down of the Abadan refinery in Iran, have had the effect of alleviating the over-capacity in Italy. Much of the country's "excess" capacity has been used to supply a growing export market ranging from areas east of Suez to West Africa and to Scandinavia ; but with the reactivation of the Abadan refinery and commissioning of the Aden refinery, Italian exporters now face serious competition. Also, some of Italy's former markets have plans to set up their own refineries, and Russia has recently been invading the Scandinavian markets. It may be recalled that the Italian Government allows refineries to sell on the domestic market the equivalent of a percentage of the plant's capacity. This arrangement, along with the Government's almost unrestricted granting of refining licences, encouraged construction of the additional capacity which now plagues this sector of the oil industry.

To conclude, trade deficit and large-scale unemployment and under-employment constitute the key problems the Vanoni ten-year development plan is striving to solve. It calls for a total investment in major sectors of the economy of 10,600,000 million lire, compared with 630,000 million in 1954. By the mechanisation of farming, further development of electric power and natural gas, and by expansion of railways, it is hoped to secure full employment and a labour distribution of 33 per cent in industry and a similar proportion in farming.

The part to be played by petroleum and natural gas (in the light of Italy's qualitative and quantitative deficiency in solid fuels) for the successful prosecution of this plan, needs no emphasis. In this context the country's twenty-nine-year-old oil law faces a major test in the application of an exploitation concession in the Pescara area, where Petrosud S.A. (owned jointly by the U.S. Gulf Oil and local Montecatini companies), which early in 1955 completed the only important oil discovery so far made on the Italian mainland, is seeking this permit. Under the old mining law the State can refuse production rights even after a discovery. But oil laws of most countries permit an almost automatic privilege of converting exploration acreage to the production phase. This Petrosud S.A. application is under study by the Higher Mines Council of the Italian Government in Rome. Whatever the outcome of this issue Italy needs energy from solid, liquid and gaseous fuels before nuclear power stations make a substantial contribution. How much the demand for energy in general, and petroleum and natural gas in particular, will increase rests largely on the attitude of the Government towards conceding exploitation permits, as well as its fuel policies, control over fuel industries, and European economic co-operation at large.

The I.R.O.M. Porto Marghera refinery at Venice

Main building of lubricating oil blending installation showing truck loading ramps in foreground

Lubricating Oil Installation for Austria

There has recently come into service at Wien-Simmering, in Austria, a lubricating oil blending installation which incorporates a modern grease unit. These facilities, which were planned in 1950 by the Shell Petroleum Company, Ltd., are expected to add materially to the domestic output of high-grade products and help to meet the increasing demands of industry. In combination with the refinery at Floridsdorf, the new units will enable Shell Austria A.G. to manufacture about 225 products or 75 per cent of home market requirements and will also use indigenous raw materials.

Three main plants form the installation, namely, one for grease manufacture, one for oil blending, and the third for the manufacture of products from mineral oils and raw chemicals. In the grease plant, which has been designed on the principle of gravity flow, high performance greases are being manufactured, including multi-purpose greases for automotive and industrial uses, while the products from the blending plant will be supplied to Vienna and to the eastern part of the country, where distribution has recommenced since the Austrian State Treaty. Metal-working oils, and oils and fibre lubricants for the textile industry, as well as agricultural and horticultural products will be prepared in the third plant. Forming part of the installation, of which we reproduce a view of the main building, are a storage tank farm, a boiler house, a transformer station, a laboratory, sixty pumps and 12 miles of pipe-lines, incorporating a system which makes spilling impossible. The plant occupies a site of about 12 acres and the main building, which is air conditioned, has exterior walls of corrugated fireproof board.

Iron Ore Deposits Near Salzgitter

The amounts of iron ore at Salzgitter, the most important source of iron ore in Germany, have variously been estimated at 1500 to 2000 million tons. Investigations carried out during the last four years between Salzgitter and Gifhorn have shown the presence of at least as much iron ore again, but in a form which, in contrast to the acid Salzgitter ore, is slightly basic, and has a higher iron content, namely, about 24 to 33 per cent. These findings were made by the "Gewerkschaft Konrad," a company formed jointly by the Ilseder Hütte iron and steel works, and the A.G. für Berg-und Hüttenbetriebe of Salzgitter. According to a statement by the last-named company, the Salzgitter deposits now yield 20,000 tons a day of the acid ore. Maximum output, it is said, is to 28,000 tons a day.

On the other hand, the Salzgitter-Gifhorn deposits are such that eight to ten mineshafts can be sunk to yield a total of 40,000 to 50,000 tons a day. The deposits, which lie at depths between 900m to 1200m, constitute the second largest in Europe, after the Minette deposits in Lorraine, of which estimated reserves amount to 6000 million tons.

All-Weather Connectors for Aluminium-to-Copper Conductors

BY OUR AMERICAN EDITOR

The growing use of aluminium conductors in electrical distribution has recently caused a demand for a safe and economical means of joining aluminium to copper conductors. Such joints must be able to stand up under exposure to severe climatic conditions. As a result of several years of research work, the Kaiser Aluminum and Chemical Corporation, Oakland, California, has now developed a range of connectors which appear to satisfy all the demands of aluminium-to-copper connections. Known as the "ALCUnector," the new unit consists of a deep aluminium cup and one of copper, welded together at the closed ends and hermetically sealed in a rubber ball and cement system.

IT is well known that aluminium conductor accessories which are used in electrical distribution circuits must to-day be usable, not only in completely new systems, but also to a very large extent in system extensions where dissimilar metals meet at various points. Thus, bare copper secondary circuits in the United States are often extended with aluminium triplex cable; copper weld primary distribution circuits are often extended with copper or ACSR conductors, and aluminium service drops are usually connected to copper house service entrance conductors. At all these junctions, at all service tappings, at all required line splices and at all terminations there is a need for fittings and connectors that are light, serviceable and inexpensive. Also, since they must be installed by distribution crews at an economical rate per day, these fittings must be simple and foolproof to apply. As a result of the above, and with the recent introduction and increasing use of aluminium conductors in the distribution field, the accessory problem immediately became acute. To meet the demand a hasty conversion of line accessories designed for copper conductors was carried out by many accessory suppliers, and these products have been used in large quantities. In a great many cases these fittings have not performed satisfactorily, principally because the physical characteristics of aluminium metal as used in conductors differ appreciably from copper and because a junction between these two metals created problems which were not anticipated.

On the other hand, such fittings performed satisfactorily in a great many installations. The cases in which connectors performed satisfactorily far exceeded the cases where they did not. However, since the wide usage of aluminium conductor in electrical distribution was a comparatively new venture, any troubles that occurred were widely publicised. The promptness with which each utility and operating company indicated its troubles with connectors has been of considerable help to the industry in cases where the deficiencies showed up almost immediately. The connector manufacturers were anxious to co-operate and as a result there are a number of designs now available which are reasonably efficient.

Differences Between Aluminium and Copper

Difficulties that arise as a result of the use of ordinary tinned copper connectors are, of course, due to the differences in the behaviour of the metals involved. The difference in the surface films that form on aluminium and copper is well known. The aluminium oxide film which forms almost instantaneously on exposure to air is of a dielectric nature, and in the case of an artificially prepared dense film may have a dielectric strength of 300V per mil (1 mil equals 0·001in). It has a dielectric constant of about 5 and a power factor under 10 per cent, both of which are readily measurable. It is therefore a true dielectric material and when aluminium surfaces are to be joined in electrical connections this film must be removed. On normal surfaces that are clean and have been in cool, dry storage for some time the oxide film may exist in thicknesses of about 50 to 60 Ångstrom units. When the aluminium part is in service and exposed to the atmosphere for a long period, where it may be subjected to higher temperatures and moisture, the oxide film builds up additionally and can achieve a thickness of several thousands of Ångstrom units. On the other hand, copper produces its oxide relatively slowly under normal conditions. Red cuprous oxide first forms and then, as the temperature becomes higher and the exposure is prolonged, black cupric oxide is formed. Both the copper oxides are, relatively speaking, semi-conductors. For example, cuprous oxide has a dielectric constant in the neighbourhood of 20. Hence these oxides have not been a real problem in the use of connectors. Best practice nevertheless is to remove the copper oxide films prior to connection. The more usual practice is simply to forget it, and in the past this has not caused much trouble.

Although it appears that a maximum potential difference of a little over 2V might be developed between aluminium and copper under ideal conditions, in fact such large open circuit potential differences are never observed. A cell made up of these two metals in the presence of electrolyte and having a metallic return circuit will cause current to flow through the electrolyte, and the aluminium anode metal will pass irreversibly into solution. In neutral electrolytes the aluminium ions are precipitated as hydrated oxide at the anodes while hydrogen ions are liberated at the copper cathodes. These will be continuously and copiously evolved as long as the galvanic conditions persist or until there is a complete loss of the anode metal.

Thermo-Elastic Ratcheting

For equal strand diameters a hard-drawn aluminium conductor has slightly more than half the yield strength of a hard-drawn copper conductor. Therefore, when tightening a copper body clamp over an aluminium conductor, pressures beyond the yield strength of the aluminium are usually developed. This causes the aluminium conductor to flow out of the joint in permanent deformation. The mating pressure that is finally sustained will be the yield strength of the aluminium. Any further tightening is inevitably followed by further permanent deformation. In practice, bronze-bodied bolted connectors are generally tightened to exceed the elastic limit of the aluminium conductor. Thus, the individual aluminium strands, which at first have only tangential contact with each other and with adjacent clamp surfaces, are subjected to very high stresses and deform quickly to give bearing areas large enough to support the applied forces at the attainable stresses. If the connector is tightened again the sequence is repeated. The supporting area increases again to sustain the new load at the same stress and, consequently, more aluminium extrudes, partly filling voids and partly flowing out of the connector body.

Since the thermal coefficient of expansion of aluminium conductor is 40 per cent greater than that of a bronze connector body, the aluminium conductor will expand at a much faster rate than the connector body when the joint is heated under current loading. As a result, mechanical pressures on the aluminium conductor increase rapidly until its yield strength is exceeded, at which point the aluminium will again flow out in permanent deformation. When the electric load is decreased, the joint cools, but as a result of the flow-out and greater contraction rate, the aluminium conductor is somewhat smaller in metal bulk under the connector than it was previously and the clamping pressure drops to a value much lower than it was originally. This so-called "thermo-elastic ratcheting" effect may continue until the electrical contact is so poor that the new I^2R losses which are introduced contribute very appreciably to heating the entire connector. The point where a runaway thermal condition can start is when the contact resistance added to load heating generates more thermal energy than can be dissipated. This usually ends with the burning of the connector or its loosening to a point where the circuit is interrupted. Large numbers of this failure as well as that due primarily to corrosion have been observed. Yet many cases of thermo-elastic ratcheting failure have been erroneously ascribed to corrosion between copper and aluminium components.

Corrosion Failures

Corrosion failures in connectors can and do occur. There is a large difference of potential between aluminium and its ions and copper and its ions. Hence, in the presence of ionised salts a bi-metallic cell is formed in which current flows from the aluminium anode through the electrolyte to the copper cathode and then returns by a metallic circuit. There is usually a metallic return circuit somewhere, but if not, electrolytic action can still take place through local concentration cells wherein the concentration of salts in one area may differ from that in another, and current flows as a result of the difference in potential caused by differences in concentration. In either form of electrolysis, the aluminium is destroyed as a conductor at the regions of activity. The process is complicated by the build-up of decomposition products and the evolution of gases at the electrodes, and an analysis of the mechanism in any given circumstance becomes very complex.

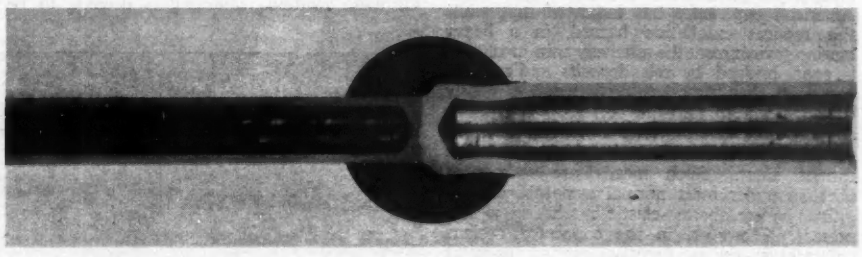


Fig. 1—Longitudinal cross section of "ALCUnector," consisting of aluminium and copper cups butt-welded together and hermetically sealed

Perhaps the most important means to reduce or eliminate thermo-elastic ratcheting has been the introduction of the all-aluminium clamp, either for bolted or compression connections. Such clamps are generally larger than their bronze predecessors and provide substantially more electrical contact surface. The clamp body at the contact areas expands at the same rate as the aluminium conductor and therefore produces no extra high stresses upon it. On cooling the joint tightness is also maintained. When high strength aluminium bolts are used in an aluminium connector the net stress variations on the conductor through cooling and heating cycles are even less than when steel bolts are used.

Several means are in general use at present to overcome or mitigate galvanic corrosion

problems. The earliest method was to plate a copper body connector with either tin, zinc or cadmium. Since these metals may have open-circuit corrosion potentials closer to aluminium there will be less open-circuit potential for galvanic corrosion. Thus, assuming that the polarisation resistances are comparable, less galvanic current should flow. A second method

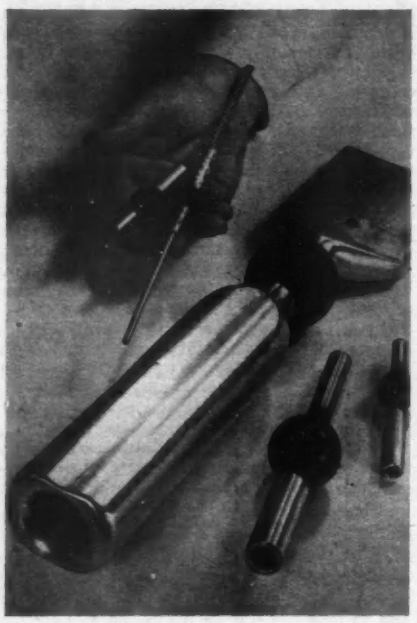


Fig. 2—Representative assortment of "ALCUnector" units for joining aluminium to copper conductors

is to place a bi-metallic washer or separator in the connector. In general, such units provided only aluminium-conductor-to-aluminium and copper-conductor-to-copper contacting surfaces. However, since the bi-metal line of separation is unprotected and is usually composed of light gauge metals, galvanic action here is found to cause exfoliation of the washer with consequent heavy corrosion working back into the current transfer paths. Some German bi-metal connector designs use fairly heavy metal components, and, in addition, their exposed bi-metal boundary is protected by an insulating material. American experience has indicated that while this reduces exfoliation hazard, in a heavy marine environment the relatively thin insulation is soon bridged by salt deposits and galvanic corrosion then proceeds unabated. A widely used method to mitigate corrosion is to seal, cover or otherwise protect the bi-metal junctions so that moisture and ionisable contaminants cannot enter. Such means are reasonably effective under most normal atmospheric conditions where thermo-elastic ratcheting is not present. However, in the connector designs currently in use in America, plating, bi-metal washers and the use of sealing pastes or covers, while very helpful, have not been found completely reliable in severely corrosive environments.

Another method of some merit is to make use of the "mass anode" principle wherein the less noble metal of a bi-metal circuit is much larger and surrounds the more noble metal. Practically, this also means the connector body should be of larger dimensions and of aluminium. Thus, it will also provide more contact area and better pressure distribution on the conductors, causing the effects of thermo-elastic ratcheting to be eliminated or made negligible. Combining such a well-designed, large aluminium connector with a good sealing paste should satisfactorily limit galvanic corrosion problems for aluminium-to-copper connections in all but the most severe industrial and sea coast areas. In such areas, however, the connector life can be expected to be shortened by steady galvanic attack due to the ever-present strong electrolytes.

Performance Requirements

It appears feasible to set up a series of requirements which an aluminium-to-copper conductor must meet in order to perform satisfactorily and reliably in any natural, corrosive atmosphere: (1) The aluminium and copper conductors must be kept as far apart as possible to avoid the possibility of an electrolytic bridge. (2) The exposed boundary of any bi-metallic junction must be kept as small as possible. (3) the exposed boundary of the bi-metallic junction must not be involved in the main current passage. (4) The exposed boundary of the bi-metallic junction must be permanently sealed against moisture or other airborne contaminants. The connector must also provide an inner barrier to prevent strand wicking between the two parts of the connector. (5) The difference in tensile and elastic properties of aluminium and copper must in no way affect the performance of the connector. (6) The differences in the thermal coefficients of expansion between aluminium and copper must in no way affect the performance of the connector. (7) The connector must provide a stable, efficient, simple means for attachment to the aluminium and copper conductors which it joins. The completed connection should withstand a tensile load compatible with its service requirements and with such additional margins of strength as to permit it to meet foreseeable emergency requirements. (8) The connector design should be relatively inexpensive to manufacture and should readily provide size ranges consistent with the sizes of conductors normally used.

The above requirements relate to an ideal connector and are based on the formation of a safe transition from aluminium to copper metal. Once such a transition is effected, the form of the connector on each side presents a much less serious problem and may be varied to suit any purpose required of the connection. A safe transition from aluminium to copper can be made by butt joining the closed ends of two tubes of these metals and suitably sealing the boundary line. The attachment of the respective conductors to this transition fixture can be made in compression barrels, with bolting members or even by soldering, brazing or welding. The three elements involved then are: (*a*) the butt joining of an aluminium member to a copper member; (*b*) the hermetical sealing of the joint boundary, and (*c*) the means for attachment to conductors or terminals.

Fabrication of Connectors

Butt joining can be accomplished in a number of ways, including soldering, brazing, arc welding, flash-butt welding and pressure welding. Of these methods soldering is deemed to be of insufficient strength. Brazing and inert arc welding lead to inter-metallic compounds of low conductance and extreme brittleness and, hence, are undesirable. Thus only flash-butt welding and pressure welding offer possibilities of effecting a strong, ductile highly conducting bond between the two metals. In the flash welding technique, the brittle inter-metallic compounds are thrown violently out of the fusion zone, leaving the bond area essentially as an alloyed interface of aluminium and copper atoms. The techniques of pressure welding differ in that the temperatures are low enough to avoid melting, formation of inter-metallic compounds or oxides. Hence the forcible removal of inter-facial material is not required as in flash welding. Either flash or pressure butt welding will produce aluminium-to-copper bonds which are very strong and which add virtually zero electrical resistance to the joined sections. The boundary between the two metals after the flash is removed then consists of a smooth line having the shortest possible length.

A stable, thermosetting insulating material of suitable size and shape is moulded over the bi-metallic boundary. This is firmly and permanently bonded to the metal surfaces using a special bonding agent. In the work under review, a ball form was chosen for the seal shape since it is the least easily torn, abraded or deformed; it sheds liquids and dirt most readily, and it presents a thick barrier to the weather which is of equal thickness in every direction. Fig. 1 shows a cross section of such a completed, straight-through "ALCUnector," designed for compression attachment to the conductors it joins. Fig. 2 shows a variety of "ALCUnectors" made in the laboratory. Some are terminal designs, some are taps, and most others are straight-through connections. For the latter, the usual method of affixing the conductors is by compression barrels. Below is presented a brief summary of the materials and laboratory pilot procedures used by the Kaiser Aluminum and Chemical Corporation in making the experimental "ALCUnectors."

In making a choice of appropriate materials, it was desired to use the same alloys for the "ALCUnector" components as are used for aluminium and copper conductors. Secondary considerations were the availability of the chosen materials and the facility of fabrication. Thus, the American "EC" aluminium alloy was first choice for the aluminium part and was used in the greatest number of connectors. This alloy is readily available in the form of ¾in diameter redraw rod and was directly usable as such for making compression barrels suitable for No. 4 A.W.G. aluminium conductor. The alloy No. 1100 is available in bars of larger sizes than ¾in diameter and was considered satisfactory for compression barrels accommodating aluminium conductors larger than No. 4 A.W.G. The copper parts were made of O.F.H.C. half-hard rod in most cases. While the first 500 aluminium and copper parts were prepared by lathe operations, it was found to be more economical to prepare large numbers of parts by impact extrusion methods and this method was found to lend itself best to the fabrication of aluminium as well as annealed copper.

In the case of copper components it was found best to shear off blanks from half-hard alloy rod, and then to anneal them preparatory to impact extrusion. In some instances cast copper parts were used where the parts were relatively large and irregular in shape. In the design of the metal cups it is anticipated that the barrier walls at the bottom of the aluminium and copper compression barrels must remain intact during and after welding and during years of service when moisture seepage along the conductor strands could possibly reach the interior. For this reason the cup bottoms were made adequately heavy to provide both flash-out metal for the welds and strong arched barrier walls for the separation of the dissimilar metals inside the connectors. The lengths and wall thicknesses are proportioned to furnish adequate strength and current carrying capacity, but not heavy enough to make crimping on to the conductor difficult.

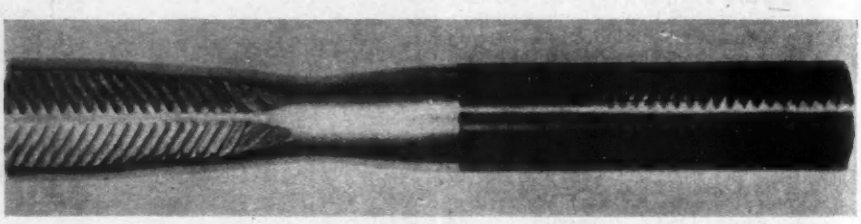


Fig. 3—1¼in diameter "ALCUnector" with pressure welded joint after having been subjected to a 15,000 lb tensile load

In the laboratory preparation of cups suitable for No. 4 A.W.G. aluminium conductor an impact extrusion operation was performed on

short sheared lengths of ¾in redraw rod. These blanks were punched with a central hole ¼in deep, preparatory to the deep extrusion. In a second punching step the complete cup was formed as the metal " squirted " upward through the annular passage between punch and die. The same punch and die served for both steps of this impact-extrusion operation and were made of plain carbon steel for the experimental work. A die lubricant was used, consisting of a water emulsion of a commercial wax. The cups were then washed in a tumbling barrel and trimmed to accurate lengths and rounded lips. Other small cups were prepared in the same way, while larger cups were prepared by lathe operations. The cups were joined together to form a strong, ductile and highly conducting weldment, either by means of flash-butt welding or by pressure-butt welding.

Experiments in flash-butt welding were done on a horizontal welding machine. The two cups were held in water-cooled split aluminium dies. They were lined up axially and under light contact with each other or with a small gap between them at the start. The welds were completed by simultaneously butting together the cups while a current of about 20,000A passed between them. The parts arced for about 0·3 second. During this time the parts melted and moved together. Then a sharp upsetting thrust was applied as the current was cut off. This action squeezed out bi-metallic liquid alloy and caused intimate joining of the base metals. Following the welding operation, the upset material was removed by turning on a lathe. In some cases the lathe operation was done in an oil-free and dry condition and a sealing cement was applied directly to the weldment at a zone around the weld. In other cases sand-blasting was employed to give a completely clean bonding zone. Following such cleaning operations, a suitable cement was applied.

Laboratory Tests

In the preparation of flash-butt welds, oscillograms were plotted automatically by the welding apparatus employed. These charts gave the relative magnitudes and the phase relationship of upset and current during the operation, thus providing a basis for judging the proper machine settings required to obtain good welds. Direct dimensional measurements gave a further check on the extent of upset, so that adjustments to make the welds as free from inter-metallic compounds as possible could be made. Frequent tensile tests on the weldments provided another quality check. Both conventional and impact tensile strength tests were used, the latter being a particularly sensitive means to evaluate weld perfection. Metallographic inspection of the polished specimens under the microscope and radiographic examination were other methods used in the laboratory to determine weld quality.

The electrical resistance values of the welds were measured as an indication of their reproducibility and also as a factor entering into their load-carrying ability. A special spring-loaded, four-terminal specimen holder allowed the rapid and accurate determination of the resistance of " ALCUnectors " in a size range up to those suitable for No. 4/0 A.W.G. aluminium conductor. Each connector was inserted in the jig, a 100A current was passed through and a d.c. resistance reading taken directly. conductor size this d.c. resistance varied from 20·5 to 23·0 microhm. It was found in general that the resistance varies with connector size, with degree of control over the welding operation and with uniformity of the removal of upset metal from about the weld.

Many tensile tests were made, both on completed connectors as such and on connectors with conductors permanently compressed in the barrels. In the latter cases the conductor would always fail before the connector showed any deformation. In tensile tests on the connectors alone, the necking down and failure invariably occurred in the aluminium member rather than at the weld, at a value corresponding to the metal strength. This is illustrated by the " ALCUnector " of 1¼in diameter, shown in Fig. 3. The aluminium has been stressed beyond its yield strength with no apparent change in the aluminium-to-copper bond. The illustrated specimen is a pressure weld. The same type of failure occurs with either flash-butt welded or pressure welded " ALCUnectors " when tested in this way.

In the development of suitable ball seal systems, the expected performance was evaluated in the laboratory by means of a moisture penetration test performed on identical seal systems. For simplicity of control, a single sealing cement was sought. After much experiment with many rubber sealing compounds, various cements and sealing techniques, a satisfactory rubber ball seal with a single-cement system was adopted.

Severe overload tests were also made on various No. 4 to No. 6 A.W.G. " ALCUnectors." Such connectors are intended to carry 135A full load and were completely stable following cycles of 500A a.c. current applied for twenty seconds in each cycle. Internal resistance as measured between points ¾in to either side of the weld averaged 22 microhms initially and remained unchanged throughout ten high-current cycles. However, the overall resistance of the connection, taken between points on the aluminium and copper conductor 1in to either side of the connector, was 195 microhms initially and increased during the ten high-current cycles to 230 microhms. This 35 microhm increase represented a slight shifting of conductors at the compression barrels. The resistance of the welds in the above tests were always less than 1 microhm when the resistances of conductor, compression joints and metal cups were deducted. When one such connector splice was loaded at 500A for sixty seconds, failure occurred by the burn-off of the aluminium cable. Another similar connector splice loaded at 1000A failed by the burn-off of the cable in twelve seconds. When a No. 4 to No. 6 A.W.G. " ALCUnector " without cable connections was bolted between two bus conductors for overload testing, it withstood 1000A for one minute with no change. Under 2000A, failure occurred at the weld after eighteen seconds.

Cyclic current loading and weathering tests on these connectors were started in June, 1953. The " ALCUnectors " were found to be stable mechanically and electrically after 400 hours of intermittent 20 per cent salt fog and full-rated current loading. Some small resistance increases occurred which are attributable to slight relaxations in the compression sleeves. A much more extensive laboratory programme, involving a more severely accelerated cyclic operational test, is currently in progress. This follows a procedure of tests which the company has been conducting on all commercially available connectors and line accessories. The cycling tests follow the sequence :

In the range from No. 4 to No. 6 A.W.G.	
(1) 2 per cent salt fog	1½ hours
(2) Dry, warm air with sun lamp	½ hour
(3) Fresh water fog	½ hour
(4) Dry, warm air with sun lamp	½ hour
Total	3 hours

The ambient temperature in the test chamber is maintained approximately at 95 deg. Fah. throughout each cycle. Each test cycle consists of three hours of the above sequence without current flowing and three hours of the same sequence with conductors loaded either to 100 or 125 per cent of full rating. The electrical resistance and temperature rise of the connectors are followed throughout the tests. The comparative changes in resistance after 222 cycles of exposure in the so-called " accelerated operational test chamber " under rated loading experienced by " ALCUnectors " and two of the best commercially available connectors installed between aluminium and copper conductors showed that the " ALCUnectors " remained completely stable throughout the test, while the best commercial aluminium-to-copper connectors increased materially in resistance and in operating temperatures. Following this full load exposure test of 222 cycles, these same " ALCUnectors " went through an additional 185 exposure cycles with current loading increased to 125 per cent of rated. No changes in cold or hot resistance or in maximum temperature were observed.

Flood Control in the Columbia Basin

At the present time, the various reservoirs of the U.S. Bureau of Reclamation in the Columbia River basin are filled and ready to supply water for the irrigation season after providing extraordinary service in helping to control the floods from heavy spring snow melt. The run-off on most streams of the Columbia River basin this year was of flood proportions and storage in reservoirs prevented several local disasters.

The peak flow of the Columbia River at The Dalles, Oregon, on June 3rd, was 814,000 cusecs. But for upstream storage this peak would have been 110,000 cusecs higher. Translated into river level, the flood crest would have been 2·7ft higher had it not been for the storage reservoirs. The Bureau of Reclamation is currently making an extensive investigation of additional storage sites on the Snake River, above Weiser, Idaho, where the water can be used for irrigation. In the Upper Snake River area the operation of Jackson Lake as a flood control reservoir reduced the peak flow at Heise, Idaho, by nearly one-fourth. The peak of 33,000 cusecs was considerably above flood stage, but severe flooding was prevented by the Jackson Lake storage and emergency dyking which has been constructed by the U.S. Army Corps of Engineers. Jackson Lake is a principal reservoir of the Minidoka Project. The Palisades dam, which is now under construction downstream, will provide an additional 1,400,000 acre-feet of capacity in this area by next year.

In the Boise Valley in Idaho, although the upstream flow was about 23,000 cusecs, the Boise River was held to 7500 cusecs at Boise by the operation of the Anderson Ranch, Arrowrock, and Lucky Peak reservoirs. Anderson Ranch and Arrowrock are Bureau of Reclamation structures and Lucky Peak was built by the Corps of Engineers as a flood control structure. Its releases are co-ordinated with those from Anderson Ranch and Arrowrock for irrigation purposes during the summer. The peak flow of the Payette River at Emmett, Idaho, reached on May 27th, was 15,000 cusecs, which is about equal to flood stage. At the same time, the Cascade and Deadwood reservoirs, upstream, were storing at the rate of nearly 12,000 cusecs. Had it not been for this storage the river, already flowing at flood stage, would have sharply increased its peak crest. Numerous other reservoirs on the Snake River and its tributaries were filling during the spring run-off and thus contributed to cutting down the crest. These included the American Falls reservoir in Idaho with 1,700,000 acre-feet capacity, and the Owyhee reservoir in Oregon with 715,000 acre-feet capacity. There is a total of 5,659,600 acre-feet of active storage capacity in existing Reclamation reservoirs on the Snake River. At the same time of peak flow several thousand cusecs were diverted from the rivers by the network of canals in the irrigated valleys of Southern Idaho.

The peak flow on the Yakima River at Parker, Washington, was about 19,000 cusecs on May 20th, equivalent to 4000 cusecs over flood stage. Had it not been for water stored in five irrigation reservoirs upstream the peak flood flow would have reached 37,000 cusecs. The Hungry Horse reservoir in Montana curtailed the peak flow of the Flathead at Columbia Falls, where it emerges from the mountains by 31,000 cusecs, or nearly one-third. The operation of this single reservoir is estimated to have curtailed the flood crest of the Columbia by more than 6in. Grand Coulee dam, the principal structure of the Columbia Basin Reclamation Project, was operated for the control of floods on the lower Columbia. In anticipation of the run-off from a record snowpack more than 2,500,000 acre-feet of storage space was evacuated, starting late in April. This loss of water sharply curtailed the power output at the dam. The reservoir space was used during the peak flood flow to reduce the flood crest of the Columbia at The Dalles, Oregon, by between 40,000 and 45,000 cusecs, or about 9in. By the time the flood peak had passed most of the Reclamation reservoirs were brimful and are now servicing irrigation schemes throughout the basin.

Personal and Business

Appointments

MR. M. SUMRAY has been appointed a director of Rubber Improvement, Ltd.

MR. W. J. PARKER has joined the staff of Mervyn Instruments, St. Johns, Woking, Surrey.

MR. DAVID H. G. INCE has joined British Oxygen Aro Equipment, Ltd., as sales manager.

MR. F. E. SHEPPARD, A.M.I.Mech.E., has been appointed sales engineer of the John Bull group of companies.

MR. K. G. BURRIDGE has been appointed works manager, and Mr. A. F. Crawford, secretary, of the International Synthetic Rubber Company.

EDGAR ALLEN AND CO., Ltd., Sheffield, states that Mr. A. P. Taylor-Gill has been appointed technical sales representative for tool steels in the North of England.

TURRIFF CONSTRUCTION CORPORATION, Ltd., 112, Colmore Row, Birmingham, 3, has announced the appointment of Mr. Frank Rabone as group development executive.

MR. J. V. STANBURY has been appointed chief designer in the motor car division of Rolls-Royce, Ltd. He succeeds Mr. W. G. Hardy, who has retired after thirty-six years in the company's service.

MR. F. W. MARTIN has been appointed deputy chairman of Simplex Electric Company, Ltd., a subsidiary of Tube Investments, Ltd. Mr. E. G. Plucknett has been appointed joint managing director.

MR. G. C. ORAM, manager of the central engineering workshops at the Appleby-Frodingham Steel Company, Scunthorpe, has been appointed, in addition, technical consultant (engineering works) to the United Steel Companies, Ltd.

BRITISH INSULATED CALLENDER'S CONSTRUCTION COMPANY, Ltd., states that Mr. O. J. Crompton, M.I.E.E., and Mr. G. H. Walton have been appointed joint general managers. These appointments follow the resignation of Mr. C. O. Boyse, M.I.C.E., M.I.E.E., who has joined Automatic Telephone and Electric Company, Ltd.

THE NATIONAL COAL BOARD has announced the appointment of Mr. R. S. McLaren as production director in the Durham division, in succession to Mr. H. E. Collins, who has recently become director-general of reconstruction at headquarters. Mr. E. J. Davies has been appointed marketing director in the South Western division.

BENNIS COMBUSTION, Ltd., Little Hulton, Manchester, states that Mr. G. M. Mellor has been elected chairman of the company. He joined the company as combustion engineer in 1931 and has been a director since 1953. Mr. Mellor has also been appointed a joint managing director with Mr. Fred Howarth. Mr. Howarth joined the company in 1914 and has been works director since 1944. These appointments follow the recent retirement of Mr. H. V. Harris from the office of chairman and managing director.

Business Announcements

MR. J. M. ROBB, manager of the overseas division of Expandite, Ltd., is touring Scandinavia.

MONSANTO CHEMICALS, Ltd., is to build a new factory on a 100-acre site at Fawley, Hants.

EDGAR ALLEN AND CO., Ltd., Sheffield, states that Mr. J. E. Dobson, tool specialist and demonstrator, has retired.

BRANDT AND ODELL state that their address is now 12, Queen Anne Street, London, W.1 (telephone, Langham 4501).

ALFRED HERBERT, Ltd., Coventry, is now the sole selling agent in this country for "Kosfeld" nut tapping automatics.

MULLARD, Ltd., states that two of its directors, Mr. T. E. Goldup, M.I.E.E., and Dr. J. D. Stephenson, M.I.E.E., are touring the U.S.A.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY, Ltd., has purchased the share capital of Toolpro, Ltd., High Road, Ilford.

DR. R. LESSING, 3, Thorney Court, Palace Gate, London, W.8, states that his telephone number has been changed to Knightsbridge 8935.

THE COUNCIL OF INDUSTRIAL DESIGN SCOTTISH COMMITTEE has moved to 46, West George Street, Glasgow, C.2 (telephone, Douglas 3914).

BROOK MOTORS, Ltd., states that it has approved the plans and placed contracts for the construction of a new factory at Honley, near Huddersfield.

DELAPENA AND SON, Ltd., Zona Works, Cheltenham, is the sole agent in the United Kingdom for Balzers high-vacuum melting and coating equipment.

GEORGE FOWELL, Ltd., has opened new premises at Middlemore Lane West, Aldridge, Staffs, in addition to the existing works at Rabone Lane, Smethwick.

SIMMS MOTOR UNITS, Ltd., states that it has acquired the design and manufacturing organisation of R. F. Landon and Partners, Craven House, Kingsway, London, W.C.2.

A.C.E. MACHINERY, Ltd., Porden Road, Brixton, London, S.W.2, states that Mr. G. Russell Jones, managing director, and Mr. A. F. Ferris, sales manager, are visiting the Zagreb International Fair.

THE LANCASHIRE DYNAMO GROUP has announced the retirement of Mr. G. S. Helme. Mr. Helme joined Lancashire Dynamo and Crypto, Ltd., as an apprentice in 1906, and from 1932 till 1953 was the company's manager in Scotland. For the last three years he has served as a consultant.

ELLIOTT BROTHERS (LONDON), Ltd., has made an agreement with the Swartwout Company, Cleveland, Ohio, by which it becomes the manufacturing licensee and sole agent in the British Commonwealth (except Canada) and Europe for Swartwout "Antronic" control and transmission equipment.

THE STEEL COMPANY OF WALES, Ltd., states that the following four firms are now accredited sheet stockholding merchants to the company :—John Cashmore, Ltd., Newport, Mon ; Ductile Steel, Ltd., Jubilee Works, Willenhall, Staffs ; John Lysaght (Bristol Works), Ltd., 66, Cannon Street, London, E.C.4 ; Roberts, Sparrow and Co., Ltd., St. Mark's Street, Wolverhampton.

Contracts

A MINISTRY OF SUPPLY contract for pressure transducers to the value of £25,005 has been awarded to J. Langham Thompson, Ltd., Bushey, Herts.

THE GENERAL ELECTRIC COMPANY, Ltd., has received an order for two 2000 s.h.p. diesel-electric equipments, one for each of two fish factory trawlers now being built by William Simons and Co., Ltd., at Glasgow, for Christian Salvesen and Co., Ltd., Edinburgh.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., has received from the Steel Company of Wales, Ltd., an order valued at £750,000, covering the electrical equipment for a four-stand tandem cold strip rolling mill. The mill is to be installed at the Abbey Works, Port Talbot, and is for the rolling of steel strip up to 50in wide at a maximum speed of 3500ft per minute. There are four rolling stands, each driven by a separate motor, followed by a tension reel, also with its own motor. The electrical equipment includes one 3500 h.p., three 5000 h.p., and one 1250 h.p. d.c. motors, two synchronous motor-generator sets for supplying the motors, and a large quantity of control gear.

THE STANTON IRONWORKS COMPANY, Ltd., has obtained an order for the supply of prestressed concrete pressure pipes and "specials" with lock joints for use in a scheme to draw water from the River Dee into the Hurleston Reservoir, near Nantwich, which is to be undertaken by the Mid and South East Cheshire Water Board ; 4200 yards of pipe, 27in diameter, 10,000 yards of 24in diameter and 5600 yards of 21in diameter are required. Because of the aggressive nature of the ground in which they are to be laid, sulphate-resisting cement will be used in their manufacture. The total value of the contract is £161,000 and work is expected to begin on the project in April, 1957. The engineer and manager of the Water Board is Mr. D. G. Davies.

Miscellanea

AIR TURBINE TESTING.—The use of turbines for air cooling was discussed on page 640, June 8, 1956, when dealing with air cycle refrigeration. To test the turbines used to cool compressor bleed air for cabin pressurisation, an electric air heater has been supplied to the R.A.E., Farnborough, by The General Electric Company, Ltd., which dissipates 180kW to the air flow. The casing is of mild steel, lagged with asbestos : working pressures run up to 75 lb per square inch and a disc designed to rupture at 80 lb per square inch can pass the full 1150 cubic feet per minute air flow. The heating elements consist of eighteen flat spirals, packed together to form a cylinder which can be withdrawn from the case without disturbing the remainder of the plant. The control gear provides staged switching of the individual sections, and an excess temperature thermostat shuts off the current in the event of the air supply not being maintained.

TURBINES AT ALTITUDE.—The August issue of the *Journal of the Aeronautical Sciences* includes a note by Karl L. Saunders promulgating a method of predicting flame extinction at high altitude in the gas turbine. Suffocation is assumed to occur at a combustion chamber pressure between 0·8 atm and 1 atm. An example evinced in support is the Bristol "Olympus," which, with a s.l.s. pressure ratio of 11, extinguishes at a combustion chamber pressure just below 0·9 atm at an altitude of 67,000ft.

WELDING SET SUSPENSION UNDERGEAR.—Quasi-Arc, Ltd., of Bilston, Staffordshire, has developed a four-wheeled "Flexitor" suspension undergear for attachment to standard 300A and 400A diesel and petrol-driven welding sets and the double-operator 300A diesel set. The undergear consists of a rear wheel assembly, and a front wheel assembly incorporating a turntable with hinged towbar, each part being designed for bolting direct to the welding set. The undergear has overrun and parking brakes which operate on the rear wheels only, and each wheel is independently suspended by a "Flexitor" suspension unit, which comprises a cylindrical shaft bonded to a rubber block which is also bonded to and contained by a flanged steel housing.

PROTECTIVE MARKING WARNING TAPE.—A self-adhesive tape called "Lasso" zebra warning tape, being marketed by Smith and Nephew, Ltd., Welwyn Garden City, is designed to provide an easily applied marking medium for protective railings, guards and machinery. It is printed in vivid yellow and black diagonal stripes, and the tape gives a clear warning of danger points. Its warning stripes are printed underneath a fine protective film so that they maintain their brilliance and are protected from such things as abrasion, moisture, alkalis and acids. This tape, which avoids the need to paint or stencil warning signs, is stated to last for years and it can be stripped off easily and quickly and used again if necessary.

BEAMA AND THE INTERNATIONAL EXHIBITION AT BRUSSELS, 1958.—We learn that BEAMA, the British Electrical and Allied Manufacturers' Association, 36 and 38, Kingsway, London, W.C.2, proposes to participate in the first post-war World Exhibition which is being held at Brussels from April 17 to October 19, 1958. The theme of the exhibition will be the contribution of the different countries of the world to the advancement of mankind and BEAMA proposes to take the initiative in organising a collective exhibit (within the power and energy section of the exhibition) to portray all aspects of Great Britain's electrical and allied manufacturing industry. BEAMA will welcome the co-operation of other kindred trade associations, to make the proposed exhibit as comprehensive as possible.

MODIFIED DIESEL RAILCAR FOR A BRANCH LINE.—In the hope of averting withdrawal of the passenger service which at present involves a loss of £14,000 a year, British Railways introduced on August 13th an experimental single-unit diesel railcar service on the 16¾ miles section of London Midland Region branch line between Buckingham and Banbury (Merton Street). The vehicle used is similar to those formed in B.R. multiple-unit diesel trains, but capable of being driven from either end. Hitherto, the B.R. diesel trains have been run as a minimum two-car formation, and the Buckingham–Banbury scheme is being undertaken as an experiment in the running of single railcars on sections where passenger traffic is very light. The service is worked by two single-unit cars. One has a seating capacity of sixty-one, the other of fifty-two second-class passengers.

MEDIUM RANGE AIRLINER.—A large airliner for economic operation over stage lengths between 200 and 2600 statute miles, has now been added to the Bristol "Britannia" series. The "Britannia" 320 is a direct development of the 310 aircraft and has "Proteus" 755 engines. The first-class cabin layout can accommodate seventy-three passengers, four abreast, and the tourist project ninety-three, five abreast, or 133, six abreast. Operating economy is such that on short sectors, such as London-Paris, of 220 miles, only thirty-two first-class passengers need be carried to break even, while over ranges of 1500 to 2000 miles this figure falls to about twenty. The cruising speed is 400 m.p.h., and to give block times competitive with jet airliners, provision has been made for rapid turn-rounds : a passenger stairway is incorporated at the cabin entry. The take-off and landing performance will allow operation from any existing first-class runway. The makers can guarantee delivery to operators early in 1958.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

MARINE ENGINEERING

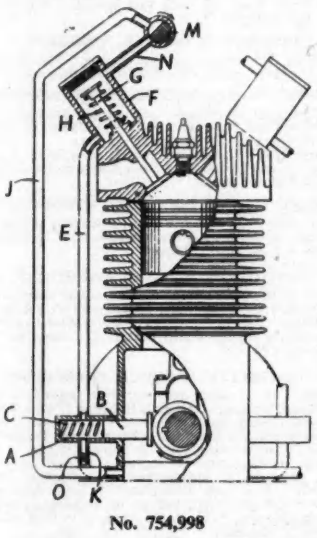
754,812. October 26, 1954.—PROTECTION AGAINST FOULING AND CORROSION OF SHIPS' HULLS, Johannes Cornelis Van Der Velde, 1162, Laan van Meerdervoort, The Hague, Holland.

The invention relates to a process for the protection of structures such as ships' hulls or metal sheet pilings immersed in sea-water or other corrosive water against fouling and corrosion by causing a direct current to flow between metal anodes and the underwater structure. According to the invention, it has been found that when using copper anodes protection against corrosion as well as protection against fouling by marine growths is obtained. Copper anodes combined with iron anodes or iron anodes with copper inlays can be used. All the anodes are enclosed by an insulating material with the exception of the side not facing the object to be protected. An apparatus is provided giving a signal when the current supply is interrupted, combined with an arrangement for automatically switching over to another source of current, such as storage batteries.—*August* 15, 1956.

INTERNAL COMBUSTION ENGINES

754,998. October 28, 1954.—HYDRAULIC VALVE-OPERATING MECHANISM, Bernard Jean Albert Chaudé, 70, Avenue de la Grande-Armée, Paris (17 ème), France.

The invention relates to hydraulic valve-operating mechanism for internal combustion engines and especially four-stroke engines. In the drawing the cylinder of a single-cylinder engine, or one of the cylinders of a multi-cylinder engine, is shown with its piston, exhaust valve, inlet valve, crankshaft and crankcase. The hydraulic circuit actuating the exhaust valve includes a reciprocating pump including a cylinder *A* in which is mounted a plunger *B* subjected to the action of a spring *C* and actuated by



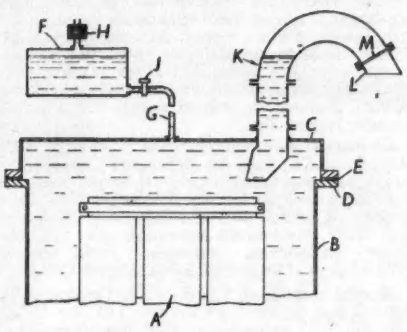
No. 754,998

a cam keyed on the crankshaft. It further includes pipe *E*, leading to a pressure chamber *F* into which projects the end of the stem *G* of exhaust valve and which houses the return spring *H* of the valve. The stem end acts as a plunger in the chamber. The hydraulic circuit also includes a return pipe *J*, a feed pipe *K*, and a reservoir for the hydraulic liquid. This liquid preferably consists of the lubrication oil of the engine, and the crankcase of the engine can be used as the reservoir. For practical purposes pipe *E* and/or pipe *J* may be made integral with the cylinder block, and chamber *F* may be incorporated in the cylinder head. It will be understood that such an engine would stop automatically if lubrication oil ceased to be present or dropped to too low a level in the crankcase, and this constitutes a safety feature of the device. The means for placing the reservoir periodically in communication with the pressure chamber and with the pump are as follows. A rotary valve *M*, located downstream of chamber *F*, with which it is connected by a pipe *N*, is rotated at a speed equal to one-half of that of the crankshaft, for instance by the shaft which controls the ignition system of the engine. A check valve *O*, located upstream of pump *A*, is so disposed as to allow only the flow of liquid from the crankcase to the pump and to prevent any discharge of the pump directly into the crankcase. A modification of the rotary valve device is also shown in the specification.—*August* 15, 1956.

ELECTRICAL ENGINEERING

754,733. February 19, 1954.—TANKS FOR OIL-IMMERSED ELECTRICAL APPARATUS, The English Electric Company, Ltd., Queen's House, 28, Kingsway, London, W.C.2. (*Inventors: Leslie Leonard Starling and Leonard Ernest Austin.*)

The invention relates to tanks for oil-immersed electrical apparatus in a tank completely filled with oil and closed except for a passage leading to an expansion chamber or header tank. According to the invention, a pressure relief device is formed by a pipe which passes through the tank top or wall and



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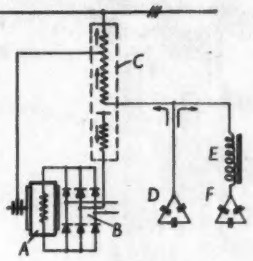
which is closed by a diaphragm which ruptures when the pressure within the tank reaches a predetermined value. In the drawing, a transformer *A* is housed within an oil-filled tank *B*. The top plate *C* of the tank is sealed to the tank body by means of flanges *D* and a gasket *E*, forming an oiltight joint, and the tank is maintained completely full of oil by means of a header tank *F*, communicating with the tank through a header pipe *G*. Changes in the volume of the oil that occur relatively slowly, for example, those due to changes in ambient temperature or to normal heating of the transformer in service, are accommodated by a flow of oil to or from the header tank *F*, which communicates with the atmosphere through a moisture-absorbent "breather" device *H*. A Buchholz protective relay *J* is located in the header pipe *G*. The pressure-relief device comprises a pipe *K* of large bore compared with the header pipe *G*, which passes through the tank top plate *C*. The pipe *K* is formed in three sections. An open-ended flanged shroud *L* is bolted to the free end of the pipe *K* and between the flanges of the shroud and of the end section there is secured a copper diaphragm *M*, approximately 0·01in thick, which closes the end of the pipe. The bottom section of the pipe *K* is fabricated to form a J-shaped bend, so that the axis of the open end of the pipe is directed slightly upwards. If a fault in the transformer results in the production of small quantities of gas, the rising bubbles of gas will pass up the header pipe *G* to operate the Buchholz relay *J*. The design of the lower end of the pipe *K* prevents these bubbles from being trapped therein, and thus rendering uncertain the action of the protective system. If, in the event of a severe fault, the pressure within the tank rises above a predetermined figure, the copper diaphragm ruptures. As the diaphragm is likely to rupture with explosive violence, the upper section of the pipe *K* is bent so that its mouth is directed downwards; the shroud *L* helps to prevent damage due to the scattering of pieces of the ruptured diaphragm. The vertical height of the pipe *K* above the tank top plate *C* is chosen so that in normal service the level of the oil never rises to fill the bent portion of the upper section. The thin copper diaphragm is thus subjected to pressure only in severe fault conditions.—*August* 15, 1956.

753,400. May 12, 1954.—ARRANGEMENTS FOR EXCITING SYNCHRONOUS GENERATORS, Siemens-Schuckertwerke Aktiengesellschaft, Berlin and Erlangen, Germany.

The invention relates to improvements in the arrangements for exciting synchronous generators and is concerned with providing exciting currents independent of load. In the drawing, *A* is a synchronous generator of relatively low power, the armature winding of which is located on the rotor, while the d.c. exciting winding is located on the stator. The machine may be constructed so as to have a three-phase stator winding which is excited with direct current, two phases being connected in parallel and in series with the third phase. The stator winding is fed through the rectifier circuit *B* from the secondary winding of a voltage transformer *C*. The primary winding of transformer *C* is series connected with the armature winding of the machine *A*, the connection being effected to a point on an individual non-interlinked phase winding of the transformer, the point being in that part, the upper, of the phase winding which is connected to the supply voltage. The second, lower, part of the phase winding feeds the condenser circuit *D*, so that these condensers are



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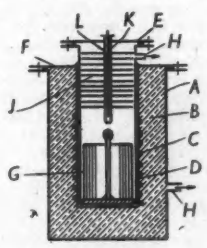
also fed by the supply voltage. Thus, since in the primary winding of the transformer *C* the current is determined by the load current of the machine *A* in the upper winding part of each phase, while at the lower part it is determined by the current taken up by the condensers, the secondary current of the transformer and, consequently, also the exciting current of the machine is composed of two components of current, one of which is dependent upon load, while the other is independent of load. There is connected in parallel with the condenser *D* a choking coil *E* which has a high magnetic iron saturation in the region of the operating value of the supply voltage. Further condensers *F* are connected in series with the choking coil *E*. Operating curves are also shown in the specification.—*July* 25, 1956.

754,920. November 16, 1954.—ANNEALING FURNACE, Allmanna Svenska Elektriska Aktiebolaget, Vasteras, Sweden.

According to the invention, an annealing furnace having a work container within the casing of the furnace for the insertion of the charge in vertical direction is fitted with a cover of sheet plate. Baffles serving as protection against heat radiation outwardly from the top of the furnace are inserted in the upper part of



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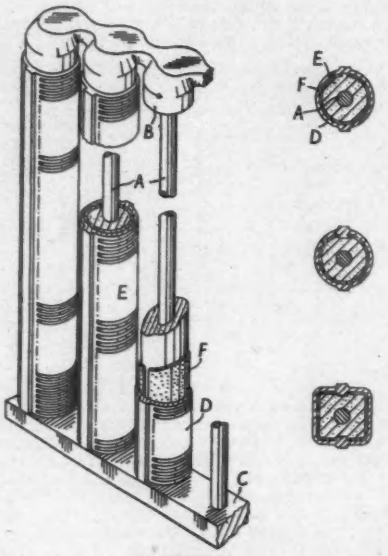
the container, the latter being fixed on the cover of the casing of the furnace. The advantage of this construction is that the height of the furnace is reduced, the construction of the cover is simplified, the weight of the cover is decreased, and that a separate evacuation arrangement for the cover is not needed. Referring to the drawing, the annealing furnace consists of an outer casing *A* containing heat-insulating material *B*, heating elements *C*, and a work container *D*. The container is provided with a removable cover or lid *E* and is fixed in the cover *F* of the furnace casing. The charge *G* is inserted vertically into the work container *D*. Indicated by *H* are connections for evacuation, if required. In the upper part of the container there are arranged baffles *J* of steel or the like, which serve as protection against radiation. These baffles may be fixed on a tube *K* mounted in the lid, in which tube a pyrometer *L* may be inserted. The annealing furnace may be provided with spring means, which support the container from below at annealing temperatures.—*August* 15, 1956.

754,661. February 1, 1954.—ELECTRIC ACCUMULATOR PLATES, The Chloride Electrical Storage Company, Ltd., Exide Works, Clifton Junction, near Manchester. (*Inventor: Robin Gray.*)

The invention relates to the tubular type positive plates of lead-acid electric accumulators, such as batteries for traction duty which have daily cycles of charge and discharge. The object of the invention is to provide tubular positive plates of improved

durability and which may also give improved electrical performance, the improved plates being simple and economical to manufacture. In the drawing the metal spines *A* which extend between the top and bottom bars *B* and *C* have around them the slitted ebonite tubes *D* held in place between the bars, there



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being active material *E* between the tubes and spines, a usual construction of tubular plates. In accordance with the invention, a thin porous lining *F* extending substantially from end to end of each tube *D* is inserted before the active material *E* is placed in it. The porous lining is a split tube which is sprung into the slitted tube. This is shown in the upper right-hand section and the centre and lower sections show modified designs.—*August* 8, 1956.

Technical Reports

Mineralöl-und Brennstoffnormen. Dintaschenbuch 20. Deutscher Normenausschuss. Berlin W.15, Cologne, Frankfurt/Main : Beuth-Vertrieb G.m.b.H., Uhlandstrasse 175, Berlin, W.15. Price DM.32.—This handbook on mineral oils and fuels has been compiled by the Sub-Committee for Mineral Oil and Fuel Standards (FAM) of the German Standards Committee on the Testing of Materials (FNM). It will be found to be of the greatest assistance to those concerned with the manufacture, use and testing of engine fuels, mineral oils, lubricants and solid, liquid and gaseous fuels, and who have to deal with the German nomenclature in these fields. The handbook contains all specifications and standards, including draft standards which have appeared up to April, 1956. Draft standards have been included because they are in many cases referred to in the standards and therefore supplement them, and also in order to give those interested the opportunity to keep abreast of developments. In addition, Handbook 20 contains a selection of standards of glass and laboratory apparatus referred to in the test specifications. Since there has been a steady expansion of oils and fuels since the war, many will welcome the present compilation of the German standards in these fields, which are as far as possible in line with those of the American Society for Testing Materials and the Institute of Petroleum.

Sur un Curieux Cas D'Alternance de Tourbillons. By E. A. Brun, L. Castel and D. Faulmann. Publications Scientifiques et Techniques du Ministère de l'Air, No. N.T.58. Paris : Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price 350 francs.—In this paper the authors investigate the formation of eddies which takes place under the following circumstances :—A rectangular tube is inserted to a certain depth into a wider, but equally high, rectangular tube, the remaining cross section of which is divided into two portions by the inserted tube. The outer tube is longer than the inner tube, and is closed at the far end. If air is blown through the inner tube oscillations are set up, with air issuing alternately from one and the other portion of the outer tube, and some air being drawn in through the opposite opening. The period of oscillation depends upon the mean velocity of the jet and the dimensions of the set-up. For a certain range of dimensions, it is inversely proportional to the air velocity and directly proportional to the inserted length of tube.

The jet was rendered visible with ammonium chloride smoke or aluminium powder, and high-speed cinematographic pictures were taken. This showed the phenomenon in detail and enabled a qualitative explanation to be given.

Launches and Trial Trips

STANCROWN, closed shelter deck cargo ship ; built by Joseph L. Thompson and Sons, Ltd., for the Stanhope Steamship Company, Ltd. ; length between perpendiculars 421ft, breadth moulded 59ft 6in, depth moulded 38ft, deadweight 11,650 tons on 28ft 10in draught ; service speed 13½ knots ; five holds, 5-ton and 10-ton derricks, electric winches ; Doxford oil engine, four cylinders 670mm diameter by 2320mm combined stroke. Launch, August 20th.

SCOTTISH COAST, cross-channel vessel ; built at Belfast by Harland and Wolff, Ltd., for Coast Lines, Ltd. ; length between perpendiculars 324ft, breadth moulded 51ft 6in, depth moulded 19ft 9in, gross tonnage 3900 ; 246 first-class and 144 second-class passengers ; two complete steel decks, twelve watertight compartments ; electric deck machinery, three 250kW diesel-driven generators, one 40kW diesel-driven emergency generator ; two Harland and Wolff, ten cylinder, two-stroke diesel engines, cylinders 560mm diameter by 900mm stroke, 155 r.p.m.—Launch, August 21st.

SHOREHAM, self-trimming collier ; built by Hall Russell and Co., Ltd., for Stephenson Clarke, Ltd.; length between perpendiculars 229ft, breadth moulded 40ft, depth moulded 18ft 9in, deadweight 2350 tons ; three holds, electric deck machinery, two 80kW and one 25kW diesel-driven generating sets ; Clark-Sulzer single-acting, two-stroke, diesel engine, 1225 b.h.p. at 215 r.p.m.—Launch, August 22nd.

DIOMED, cargo liner ; built by The Caledon Shipbuilding and Engineering Company, Ltd., for Alfred Holt and Co. ; length overall 492ft, breadth moulded 62ft, depth moulded to upper deck 35ft 3in ; six cargo holds, seven deep tanks, one 70-ton, eight 10-ton and eighteen 5-ton derricks and one 7-ton derrick for engine-room service, electric winches ; two 450kW diesel-driven generators, one 350kW emergency diesel-driven generator ; Kincaid turbocharged, single-acting diesel engine, 8000 b.h.p. at 112 r.p.m.—Trial, August 23rd.

NABEUL, cargo ship ; built by the Chantiers de Bretagne for the Compagnie Daher Marseilles ; length overall 285ft 5in, length between perpendiculars 262ft 6in, breadth moulded 41ft 6in, depth to upper deck 23ft, draught 16ft 9in, deadweight 2300 tons ; grain capacity 123,600 cubic feet, service speed 12·5 knots ; one supercharged M.A.N. mark G.9.V.46.66 diesel engine, 2350 h.p.—Trial, August.

FORT ST. PIERRE, banana carrier ; built by the Chantiers Reunis Loire-Normandie for the Cie Generale Transatlantique ; length overall 377ft 4in, length between perpendiculars 346ft 1¾in, breadth moulded 51ft 10in, draught loaded 21ft 4in, deadweight 2800 tons, insulated capacity 6000 cubic metres, speed at 5900 tons displacement 17 knots ; three 250kW diesel-driven generators ; one mark 10,62 V.T.F. 115 two-stroke, single acting, Burmeister and Wain diesel engine, 6000 b.h.p. at 150 r.p.m.—Trial, August.

IVAN PAVLOV, cargo ship ; built by the Chantiers Navals de la Ciotat for Russia ; length overall 425ft 5¾in, length between perpendiculars 395ft 8in, breadth moulded 55ft 1¾in, depth to upper deck 33ft 2in, draught loaded 22ft 4in, deadweight 6170 tons, four holds, bale capacity 318,000 cubic feet, one 60-ton, one 40-ton, four 10-ton and four 5-ton derricks, electric winches ; service speed 13 knots ; one set of Rateau-Chantiers de Bretagne geared turbines 4500 h.p. at 120 propeller r.p.m. ; two Babcock and Wilcox boilers supply steam at 455 lb per square inch and 750 deg. Fah.—Trial, August.

Catalogues and Brochures

THE PYRENE COMPANY, Ltd., 9, Grosvenor Gardens, London, S.W.1.—Brochure entitled "Caught Red-Handed," describing a new "Rate-of-Rise" fire detecting system and signal retransmission equipment.

THE STANDARD AND POCHIN BROTHERS, Ltd., Evington Valley Road, Leicester.—Illustrative catalogue dealing with "Calorier" unit heater designed for the heating of industrial and commercial premises, i.e. factories, garages, aircraft buildings, workshops, departmental stores and large offices.

NEWTON, CHAMBERS AND CO., Ltd., Thorncliffe, near Sheffield.—Illustrated brochure describing needle metallic recuperators, designed to obtain maximum heat exchange by convection. These recuperators can be applied to all types of industrial furnaces and are suitable for preheating both air and fuel gas.

GEORGE KENT, Ltd., Luton.—Publication TP5009/856, entitled "Control of a Sulphur Recovery Plant," is reprinted from "Process Control and Automation," and describes the instrumentation and control plant installed by George Kent, Ltd., for a sulphur recovery plant at a chemical works in North-West England.

THE ENGLISH ELECTRIC COMPANY, Ltd., Welding Electrode Division, Clayton-le-Moors, Accrington.—Publication No. WA/134, describing "Fillerees" electrodes developed for filling cavities in steel castings. Also publication No. SG/335, giving details of this company's ranges of standard current transformers for use on equipments up to 15kV.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Sept. 7th.—LIVERPOOL BRANCH : Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, Chairman's Address, F. T. Bartho, 7.30 p.m.

Mon., Sept. 10th.—CENTRAL LONDON BRANCH : White Hall Hotel, Bloomsbury Square, W.C.1, "Motor Control Gear," W. J. Johnson, 7.30 p.m.——N.W. LONDON BRANCH : Century Hotel, Forty Avenue, Wembley Park, Chairman's Reception, Film of Electrical Engineers' Exhibition, 1956, 8.15 p.m.

Tues., Sept. 11th.—BOURNEMOUTH BRANCH : Grand Hotel, Firvale Road, Bournemouth, Dissertation on Thirteenth Edition I.E.E. Regulations, E. J. Sutton, 8 p.m.——TYNESIDE BRANCH : Evening Visit to Stella Power Station, 7 p.m.

Wed., Sept. 12th.—HALIFAX BRANCH : Crown Hotel, Horton Street, Halifax, "Oils and Greases," accompanied by Films, "Thin Film Lubrication" and "Lubricating Greases," G. Stott, 7.30 p.m.

Thurs., Sept. 13th.—S.W. LONDON BRANCH : Prince of Wales Hotel, S.W.19, Film and Commentary, "Fifth Electrical Engineers' (A.S.E.E.) Exhibition," P. A. Thorogood, 8.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Sept. 26th.—LONDON BRANCH : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Some Aspects of Transistor Progress," H. W. Loeb, 6.30 p.m.

BRITISH INTERPLANETARY SOCIETY

Sat., Sept. 8th.—Caxton Hall, Caxton Street, London, S.W.1, "Rocket Development in the U.S.A.," F. C. Durant, 6 p.m.

CORNISH ENGINES PRESERVATION SOCIETY

Sat., Sept. 8th.—Camborne, Annual General Meeting.

INCORPORATED PLANT ENGINEERS

Mon., Sept. 10th.—DUNDEE BRANCH : Mathers Hotel, Dundee, "The Application of Work Study and Incentives to Maintenance," D. Gardiner, 7.30 p.m.

Tues., Sept. 11th.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, Chairman's "At Home," 7.15 p.m.

Wed., Sept. 12th.—SOUTHERN BRANCH : Visit to Wilton House and Carpet Factory, 2.30 p.m.——WESTERN BRANCH : Grand Hotel, Bristol, "Ventilation and Air Conditioning," J. R. Kell, 7.15 p.m.

Thurs., Sept. 13th.—N.E. BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, "Light for Industry," R. J. Fothergill, 7 p.m.——MERSEYSIDE AND N. WALES BRANCH : Stafford Hotel, City Road, Chester, "Industrial Pneumatics," F. X. Kay, 7.15 p.m.——GLASGOW BRANCH : Scottish Building Centre, 425–427, Sauchiehall Street, Glasgow, "Rockets and Space Flight," P. H. Tanner, 7.15 p.m.

INSTITUTE OF PETROLEUM

Wed., Sept. 19th.—26, Portland Place, London, W.1, "Diesel Combustion Study by Infra-Red Emission Spectroscopy," W. T. Lyn, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Thurs., Sept. 13th.—MIDLANDS ASSOCIATION : Visit to the new pit at Lea Hall Colliery, Near Rugeley, Staffs, 2 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Sept. 10th.—Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, Chairman's Address, Informal discusion on "Design," 7.15 p.m.

Thurs., Sept. 13th.—38, Portland Place, London, W.1, "Function, Appearance and Production : Three Angles on Good Design," L. Bruce Archer, 6.45 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Sept. 26th.—GENERAL MEETING : Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, Presidential Address, J. F. B. Vidal, 5.30 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Thurs., Oct. 11th.—Weir Lecture Hall, 10, Upper Belgrave Street, London, S.W.1, "Scale Effect Experiments on Victory Ships and Models," Part II, "Analysis of Wake Measurements on a Model Family and the Model Boat, D. C. Endert, Jr.," J. D. van Manen, 4.45 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., Sept. 12th.—DUNDEE SECTION : New Imperial Hotel, 15, Tally Street, Dundee, "Materials Handling : With Particular Reference to Batch Production," W. P. Kirkwood, 7.30 p.m.——EDINBURGH SECTION : North British Hotel, Princes Street, Edinburgh, Ladies' Night and Film Show, 7.30 p.m.

Mon., Sept. 17th.—COVENTRY SECTION : Craven Arms, High Street, Coventry, "Development of German Transfer Machines," Film and Discussion, 7 p.m.—MANCHESTER SECTION : Reynolds Hall, College of Technology, Sackville Street, Manchester, "CO_2 Process Applied to Core Making," A. Talbot, 7.15 p.m.

Wed., Sept. 19th.—BIRMINGHAM SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, Film Evening, "Automation," 7 p.m.——WOLVERHAMPTON GRADUATE SECTION : Technical College, Wulfruna Street, Wolverhampton, "High-Speed Press Work," J. A. Grainger, 7.30 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Oct. 11th.—The Temple, Dale Street, Liverpool, Presidential Address, W. Rose, 7 p.m.

OLD CENTRALIANS

Fri., Sept. 14th.—The Mapleton Restaurant, Coventry Street, London, W.1, "Cathodic Protection," H. G. B. Nolan, 12.45 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

To-day, Sept. 7th.—FAWLEY SECTION : Copthorne House, Fawley, Hants, "Instruments in the Steel Industry," W. Swinn, 7 p.m.

Tues., Sept. 25th.—MAIN MEETING : Manson House, Portland Place, London, W.1, Presentation of the Bowen Prize. "The Accurate Calibration of Flowmeters," E. A. Spencer and A. T. J. Hayward, 6.30 p.m.

Fri., Sept. 14th.—MIDLAND SECTION : Regent House, St. Phillips Place, Colmore Row, Birmingham, 3, "The Instrumentation of a Space Vehicle," N. R. Nichol, 7 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Fri., Oct. 19th.—39, Elmbank Crescent, Glasgow, Symposium on the Application of Low-Alloy Steels for Welded Pressure Vessels, 10 a.m.